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# HANDBOOK OF
# MACHINE SHOP MANAGEMENT

THE • MAPLE • PRESS • YORK • PA

# PREFACE

This book has been written with a definite purpose and from a carefully selected viewpoint.

The purpose was to make available to all machine-shop executives, and men in training for machine shop executive positions, a useful book on the study and solution of problems in management.

Two tests have been applied to all the material that has entered the book. In question form the first was: "Does this relate to an element or mechanism of machine shop management that is actually in use?" A negative reply was sufficient immediately to reject the material. If the answer was affirmative, the second question was asked: "Can the element or mechanism described be used in all probability, in other machine shops?" If the reply was again in the affirmative, the material was used, if not it was thrown aside.

The viewpoint selected in preparing this book is a bold departure from that which has governed previous works on shop management. This can be best shown by drawing a parallel between machine design and shop-system design.

In the field of machine design, we have many excellent handbooks which give fundamental data on the design of machine elements as shafts, bearings, gears, pulleys, clutches, and the like; but we have no book, aside from college text books, which purpose to tell the machine designer how to design a machine. That is, the machine designer uses no book that sketches a method, which begins perhaps with the base, builds up the housings for the bearings, fits in the shafts, the driving pulleys, the gearing, and other operating parts to produce a machine. The reason for this is obvious; the design of no two machines can be attacked in identical fashion, but fundamental data on design apply to all. This is the information that the designer needs and seeks.

Many books have been written on industrial and shop management, but they have taken the viewpoint that the reader wished to be told how to design a system. The giving of fundamental data on the elements and mechanisms that entered that system has been a secondary consideration. This viewpoint while perhaps proper in the past is wrong today.

Thus this book does not outline any system of management. It does not tell how to design any shop system; for it recognizes that shop conditions differ tremendously. The methods of attack and solution are as different in the designing of shop systems as in the designing of machines.

This book is then a "Handbook of Machine Shop Management." In it has been gathered together all of the available information on machine shop management which would stand the tests of the

two questions stated above. This information is presented in a clear, concise, handbook style, with the belief that the machine shop executive can select the elements and mechanisms that he needs and work out his own methods of fitting them together into a systematic whole.

One of the features of this book is its treatment of standardized equipment which is as important as a standardized product. Very little on this subject has been available in published form and it is believed that those standards which appear in the Handbook will be of particular service.

In determining the value of a proposed improvement, be it in methods, men or machines, the factory executive will find a definite criterion in the three regulative principles of management as developed by Messrs. Alford and Church. If the step contemplated will add to the **systematic use of experience; the economic control of effort**; or the **promotion of personal effectiveness**, it may be accepted as of worth. The extent of its value must be measured by the degree to which it will enlarge their effectiveness.

Many sources of information have been made available and used, and are mentioned in the text. The columns of the *American Machinist* have been the greatest single source of helpfulness as will be noticed by frequent references throughout the book.

JOHN H. VAN DEVENTER.

NEW YORK,
*January*, 1915.

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# HANDBOOK OF MACHINE SHOP MANAGEMENT

## ORGANIZATION

**1. Organization.** Organization is the mechanical structure through which the functions of management are applied. The form of organization itself has nothing to do with the individuals forming part of it, but it defines the responsibilities and authorities of these individuals and also their relation to others. Several distinct types of organization are in use and many special combinations are found. Regardless of the form employed, those connected with the management of every factory large or small should

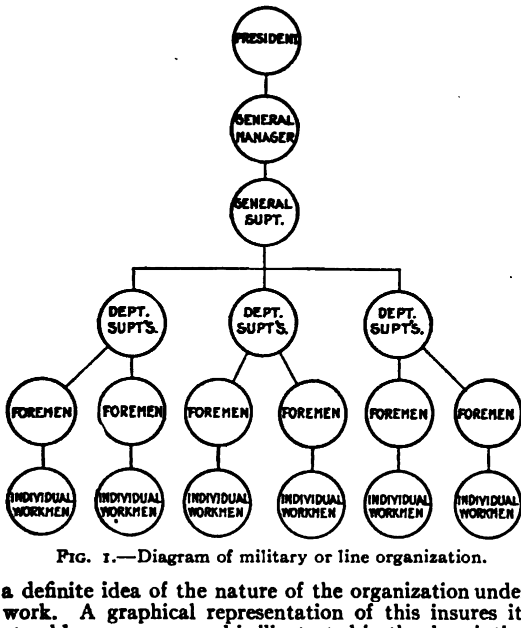



FIG. 1.—Diagram of military or line organization.

have a definite idea of the nature of the organization under which they work. A graphical representation of this insures its being understood by everyone, and is illustrated in the description of the special organization types.

**2. Military type, or line organization.** This is the most common type, illustrated by diagram in Fig. 1. The connecting lines show

the course of authority and information. The *advantages* of this type of organization are the very *definite authority* which is placed on the different units, which in turn definitely places responsibility and leads to *good discipline*. The *disadvantages* are in the necessary *repetition of orders*, and the *slow and restricted transmission of information*. The efficiency of this type of organization depends largely on the personal make-up of its members. Where they are well informed on the work which they handle, provided with sufficient assistants, and are good leaders, there is no stronger type of organization than this.

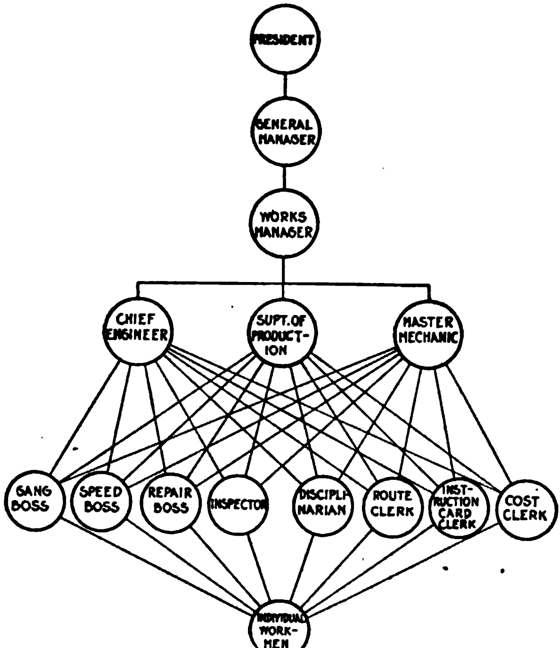



Fig. 2.—Diagram of functional or staff organization.

**3. Functional or staff organization** is illustrated in Fig. 2. It differs widely from the military type in that the workman receives *orders* and instructions on different points from a number of superiors who are equal in authority. Each of these is supposed to be a *specialist* in his line and to be therefore best posted to instruct the operator in the particular part of the work coming under his supervision. The *advantages* of this type of organization are the *quick transmission* of information and orders, the *diverse information* available, the more even *adjustment* of the foreman's load; its *dis-*

*advantages* are chiefly due to *a lack of discipline* and the tendency of *authority to overlap*.

**4. A peculiar hybrid type of organization in successful use.** An original and effective form of organization exists in a large New England clock factory. The general type follows the military plan. The peculiar feature rests in the privilege allowed to any member of the working force to originate orders. No restriction is put upon their nature, or the amount involved, but the right of veto is exercised by the immediate superior, and all orders are passed upon before execution. The result of this procedure has been effective in bringing to the attention of the management those whose initiative and ability qualify them for advancement, and the majority of responsible positions in the plant are filled by those who were discovered in this manner. The most suitable term for an organization type of this kind would probably be the word "communistic," but aside from its peculiar nature it has worked to advantage in the factory using it, which is above the average in size, employing three to four thousand people.

**5. Psychology of standardization.** The value of standardization of methods is based upon the reluctance of the mind to grasp new conceptions. Thinking is most easily done when the thoughts are related to each other, or are suggested by experience. The value of standardization lies in the fact that the original thinking is done but once in choosing the best way to be adopted as a standard, this is then recorded in reference form, and when the occasion arises for the repetition of the standardized act it becomes merely a matter of reference and does not have to be thought out. Standardization therefore is not only valuable as showing the best way to do certain things, but it saves mental labor for those in charge of the work, giving them time and energy to apply on something else.

## SYSTEMS

**6. Temporary systems.** Temporary systems are often installed for short periods for purposes of securing special information or of effecting the special control of some elements of activity. As an example, the time spent by employees in waiting for service from a certain crane, or in delays caused by repairs to the belts of their machines, might not warrant the use of a continuous system, but would pay for short investigations by means of temporary systems of time keeping to determine if another crane would be a good investment, or if it would pay to work the belt repair gang after hours to do away with the delay.

As an example of the use of a temporary control system, suppose that a temporary information system should have disclosed the fact that too long a time was elapsing after the whistle blew in the morning before the machines in a certain department were cutting at full rate. This is something that could not be found out through the regular time system which as a rule takes no account of the hourly rate of production but gives the average only. In an electrically driven department, it could easily be found by attaching a volt and ammeter to the driving motor circuit and taking readings without the knowledge of the department concerned. Or it could

also be done by installing a temporary first-hour production time-keeping system which would determine the ratio of the amount of work during that hour to the average for the day. The correction would be made by the use of a temporary penalizing system which would be kept in force until the objective point becomes impressed as a habit, or standardized. If kept in use after this it simply becomes a portion of red-tape. Often, the moral effect of the short continuance of the first-hour production time-keeping system would be sufficient in itself to correct the error.

**7. Systems.** A system is nothing more than a standardized method, or combination of methods. Its value lies in the standardized methods which it defines, and not in the printed forms used in connection with it. What is called a "general system" is a collection of little systems each employed for a definite purpose. The following partial analysis of a "general system" illustrates this point.

| | | | |
|---|---|---|---|
| General System. | Order Systems. | Purchase | Methods of requisitioning.<br>Methods of filing orders.<br>Methods of hurrying delivery. |
| | | Production Order and Sub-order | Methods of issuing.<br>Methods of executing.<br>Methods of filing. |
| | | Tracing and Routing | Methods of planning work.<br>Methods of recording movements.<br>Methods of tracing work. |
| | | Drafting Room | Conventional methods.<br>Methods of filing.<br>Method of issuing. |
| | Time Systems. | Pay Roll. | Method of figuring.<br>Method of distributing.<br>Method of paying. |
| | | Compensation. | Rate setting methods.<br>Piece or premium systems.<br>Employment and discharge methods. |
| | | Cost. | Expense computing methods.<br>Material pricing methods.<br>Labor apportionment methods. |
| | | Time Keeping. | Registration methods.<br>Men numbering methods.<br>Filing methods. |
| | Transportation and Storage Systems. | Tool Supply. | Tool check methods.<br>Tool delivery methods.<br>Tool collection methods. |
| | | Stock Room. | Material orders.<br>Bin methods.<br>Methods of issue. |
| | | Store Room. | Stores order methods.<br>Methods of issue.<br>Inventory of stores. |
| | | Shipping. | Methods of recording.<br>Methods of tracing. |

**8. When to change methods and systems.** There should be distinct advantage in a new method or system before discardin an old one in its favor. *Methods, like machines, have a first cos* and must pay for themselves within a certain period to be goo investments. And where in the case of a tool it is a question o training one man or at most a few men to its use, with methods o systems, the installation of new ones requires the training o many. Energy savings, however, are of more importance i systems than with tools, and where a tool which would save

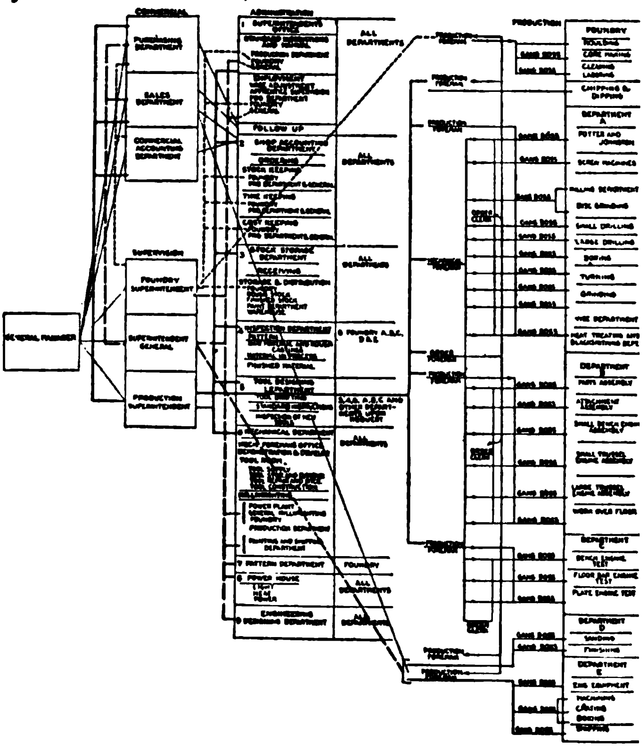


FIG. 3.—Organization chart.

per cent. of the energy of an operator would not necessarily appea to the manufacturer as a good investment, a new method or syste which would result in a 5 per cent. saving of the energy of a numb of executives and department heads would be a fine thing, even it did not make any material difference in the cost of the product.

**9. System in the small shop.** The small shop can benefit b the use of proper methods as well as the large one. It need

proper means of looking after and issuing small tools for example, even if the foreman is the tool tender, which often happens. There is no reason, also, why the work of the small shop should not be planned, nor is there any reason why time study of the things that are done should not be of benefit and profit. In fact, all the elements of big shop management can be applied to the small shop, although there must be more combining of functions in one man and less specializing. And it is quite necessary to get these things started before the shop begins to grow and get beyond control. It is much easier to do this than to have to change methods radically in a large plant with its greater variety of items to contend with. *The process of standardizing, for example, is comparatively easy when there are but few things to standardize.* Time study,

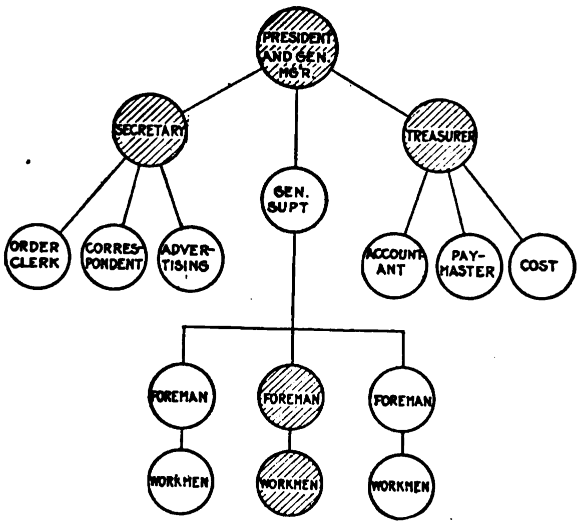



FIG. 4.—An organization for a small shop. As it grows, the unshaded circles are filled.

standardization methods, compensation schemes, tool crib and check systems, stores systems and costs as applied to the small shop will each be treated under a separate heading. In considering their value, the small shop manager must remember that his business is going to grow, and that at some stage of its growth he will be forced to adopt systematic methods and standards through self-preservation. And he will find in most all cases that the present introduction of such methods instead of proving a burden will lighten his load and that of any assistants that he may have. (See Fig. 3.)

**10. One of the uses of an organization chart is to define rity and the functions of those connected with it. The**

chart shown here, reproduced from the American Machinist, and representing the organization of the Root and Van Dervoort Co., shows how definitely the scope of activity of the different units is outlined. (See Fig. 4.)

## COMMITTEE PLANS

**11. The committee plan in management.** The old idea of good management consisting of rapid-fire decisions is being replaced to advantage by committee and conference work. This is particularly true in large organizations, some of which have committees and sub-committees organized to cover almost all branches of activity. Conferences are held at frequent intervals in order that points which arise may be thoroughly discussed. The importance of correct judgment even in small decisions, and the many varying points of view from which any matter may be considered, render it advisable to take up anything outside of the regular routine in committee conference where possible.

Committee or conference work is not restricted to the principal executives of the plant, but is carried down through the ranks as far as possible. For instance, no more effective way could be devised to interest the workmen in the cause of safety than the formation of safety committees comprised of one executive and a number of workmen.

**12. To make committee and conference work a success,** it is necessary to hold meetings at regular periods. As an example of a conference schedule, the following may be copied to good advantage. It is taken from the Root and Van Dervoort Co.'s practice.

**Root and Van Dervoort Conference program.** A monthly conference is held between the superintendents and the sales manager at the end of each month, in which a schedule of production is laid out for the third month in advance. The schedules for the two intervening months are gone over and such slight changes as are desirable, but which do not interfere with the manufacturing, are made.

Weekly conferences are held between the production superintendent, the order foreman and the follow-up clerk, for the consideration of production progress, going over the work for the past week and crystallizing plans for the following weeks.

A conference is held each week between the foreman of the shipping department, the follow-up clerk and the sales department, in which a schedule of shipments for the ensuing 2 weeks is made, the schedule for the second week being laid out in a general manner, and crystallized definitely at the following conference.

A conference is held each week between the follow-up clerk, the superintendent of the foundry and the order foreman, in which foundry deliveries are arranged to suit the machining requirements.

A weekly conference is held between the follow-up clerk, the mechanical foreman and the purchasing department, in which all incoming supplies and tools are checked over, deliveries being ascertained on those needed, and hurried when necessary. Immediately after this a similar conference is held with the order foreman, in which all incoming material going into production is gone over, he calling attention to specific requirements, deliveries being ascertained and, where necessary, expedited.

A weekly conference is held between the superintendents, general foremen, gang bosses, and heads of the administrative departments to freely discuss shop conditions of all kinds and methods for improvement.

Daily conferences are held between the follow-up clerk, the foreman of the shipping department, the order foreman and the stock-storage foreman, in which the daily progress of production is gone over and deliveries on shortages on shipments and repairs expedited, insuring the utmost dispatch.

# HANDBOOK OF MACHINE SHOP MANAGEMENT

## FUNCTIONS OF DRAFTING DEPARTMENT

**17. Management applied to designing and drafting.** *The three regulative principles* mentioned in the introduction as being fundamental to management in all its branches, apply to the designing and drafting department very forcibly, and there is possibly a more virgin field here than anywhere else. Drafting and design come first, provide the base for the structure which is to be built, and are deserving of the best management which can be applied, yet they are often quite neglected in this respect, being considered undesirable but necessary.

**18. The systematic use of experience,** is ably represented in design, when we make use of past results, not only our own, but those of others, in creating new forms from old units. Aside from this, it bears on many other activities in these departments, among which may be listed: *the standardization of product; the standardization of tools; the standardization of drawings.* (As to size, form and construction.) *The standardization of methods* of handling, filing, indexing and issuing. *The standardization of information.* (Data books, lists, records, and the like.)

**19. The economic control of effort** is indicated in these departments in the general form of organization which is adapted to the nature of the work. It underlies the control of the following elements: *The division of labor* between designers, detailers, constructors, tracers, and the rest. *The elimination of unnecessary work,* through application of the standardized methods mentioned above, and through proper instructions. *The elimination of errors,* through efficient checking. *The maintenance of routine,* through the application of standardized methods. *Compensation,* which, to be on an economic basis, must be accompanied by correct judgment of capabilities.

**20. The promotion of personal effectiveness** presents perhaps more possibilities when applied to these departments than many others. It is something that cannot be measured by a system, nor furthered by hard and fast methods, but *depends* largely *upon the qualities of leadership.* In designers and draftsmen we have material of a high order, capable of great personal effectiveness; their work is largely creative, and the quality of thought put into it sets the standard all through the plant. Hence the necessity of chiefs in these departments who have not only the qualities of leadership, but are capable of developing individual effectiveness to a high degree. With such leaders, the work of the designing department becomes almost an inspiration. Without the development of personal effectiveness, even when experience and the control of effort are evident, the work becomes merely routine.

**21. Requisites of an efficient drafting room system are:** Easy filing and indexing of tracings and sketches. Use of standard forms and sizes of drawings. Use of standards in design. Planning

work in the department. Complete lists and indices locating, with least references, drawings, patterns, tools, and the like, facilitating information for shop orders, stock orders, purchases, assembling.

**22. Outline of designing and drafting department functions.**

Design:
- New designs.
- Alterations, corrections and improvements.
- Design tools, jigs and fixtures.
- Establish standards for product parts.
- Establish standards for tools and jig parts.
- Compile data sheets,
  - of standard parts.
  - of standard tools.
  - of available supplies, fittings, and so on.
  - of machine tools, and their parts.

Supplementary:
- Design.
- Detail.
- Construct.
- Trace.
- Check.
- Print.

And sometimes:
- Estimate on new work.
- Supervise processing and routing.
- Inspect finished machines.

Routine:

| | |
|---|---|
| Indexing. | Drawings, sketches, data sheets, and so on. |
| Filing. | Drawings, sketches, data sheets, and so on. |
| Recording. | Changes, pattern numbers, symbols, machine numbers, location of blueprints. |
| Compiling. | Lists and bills of material. |
| Issuing. | Blueprints. |
| Making. | Books of assemblies, unit assemblies, and so on. |
| Ordering | Special purchased parts and constructions. |

## SYSTEMS OF NUMBERING PRODUCT PARTS

**23. Numbers and symbols and their relation to drawings.** A numbering or symbolizing scheme must have its origin in the drafting department. The following are some of the numbering schemes in common use:

**24. The mnemonic system,** in which the designation is made in such manner as to convey to the mind a quick impression of the common name. For example, a 36-inch boring machine could be given the type symbol—36BM. The various parts would then be 36BM-1, 36BM-2, and so on. Unless drawings are filed as described in 42, under the portfolio system, the use of these symbols necessitates a cross-index to the drawing location number. The advantage is that the symbols are easier to learn. This does not apply necessarily to the parts, however, unless the product is of one type of machine. Pattern numbers usually correspond to the symbols.

**25. The decimal system,** in which a whole number represents the machine, and decimals are used to represent the parts. For example, the boring machine mentioned above might be termed 100. The various parts would be 100.01, 100.02 and so on. If more than 100 parts are in one machine, 100.101, 100.102 may be used. The cross-index is necessary in this case unless draw-

ings are filed in groups under the machine number. The advantage is that a part can be distinguished from the complete machine by the nature of the symbol. This does not seem to be a compelling advantage however.

**26. The straight numerical,** in which numbers are assigned in succession to parts drawn, regardless of whether the drawing shows a complete assembly or a part. Drawing numbers are applied to correspond, the drawer number being omitted. Pattern numbers usually correspond. This system is a simple one, necessitating the least amount of cross-indexing. It is almost impossible, however, to acquire a familiarity with many parts by number. This may not be a great disadvantage since the numbers are readily obtained from lists and drawings.

| | | | |
|---|---|---|---|
| 1 | 11 | 21 | 31 |
| 2 | 12 | 22 | 32 |
| 3 | 13 | 23 | 33 |
| 51 | 201 | 301 | 401 |
| 52 | 202 | 302 | 402 |
| 61 | 203 | 303 | 403 |
| 62 | 204 | 304 | 404 |
| 63 | 205 | 305 | 405 |
| 64 | 206 | 306 | 406 |
| 65 | 207 | 307 | 407 |
| 101 | 208 | 308 | 408 |
| 102 | 209 | 309 | 409 |
| 103 | 210 | 310 | 410 |
| 104 | 211 | 311 | 411 |
| 105 | 212 | 312 | 412 |
| 501 | 601 | 701 | 801 |
| 502 | 602 | 702 | 802 |
| | | | |

Drawer No. - 1 to 50 = Foreign
" 51 to 60 = Sketches
" 61 to 80 = Lists
" 101 to 500 = Product Drawings
" 501 to 900 = Tools, Jigs etc.

FIG. 5.—Arrangement of tracing cabinet allowing for unlimited extension.

**27. Drawer number and sheet,** in which the part is designated by a drawer number and sheet by which the tracing is located. This necessitates the restriction to *one detail* on each sheet, which is commonly accepted as the best practice.

Drawings are numbered 6–36, and so on, the first figure representing the drawer number in which the tracing is filed, the second the location of the sheet in the drawer.

No effort is made to keep drawings of similar machines or similar parts together, the size of the tracing and the capacity condition of the drawers determining the location. (See Fig. 5.)

Where parts are numbered to correspond with the sheet and drawing number, and patterns likewise, a simple indexing system will suffice. The disadvantage is that parts are not likely to be-

come known by sheet numbers in the shop. This objection does not have great weight in shops manufacturing large varieties in one department. For this class of work, it is a good scheme.

**28. Class symbols by unit assemblies.** Where the product is exceptionally well standardized, the class symbol system may be used. A given complete machine has its class symbol. For example, the complete assembly of a certain chassis may be termed *A*. Motors of a given type, *M*. Transmissions, *T*. Rear axle, *RA*. Front axle, *FA*; and so on. Thus, *A–FA* would be the front axle assembly of a given size and type of car, and *BM* the motor of another type of car. Under the class symbols come numerical designations of the parts, which are fewer than with other less completely classified schemes. Thus, *A–T*4 might represent one of the shifting gears in the transmission of a class *A* car.

The advantages of this system are that each type of part being restricted to one department, or a few at most, the shop men have no difficulty in becoming familiar with the symbols, and the double system of names common in most shops is done away with. In addition it affords first-rate classifications for filing records, costs, making comparisons of similar parts, issuing stock orders, and the like. The objection to double drawing symbols does not weigh as heavily, as a few standard designs constitute the entire product. A shop with a large variety of types of output would be at sea, however, if such a system were used.

## STANDARDIZATION OF DRAWINGS

**29. The standardization of drawings** is best effected through specific instructions issued to draftsmen, outlining *standardized practice*. A sample set of instructions is as follows:

DRAFTING INSTRUCTIONS, STANDARD MFG. CO.

1. The third-angle projection is to be used exclusively.
2. Sizes of drawings to be as follows:

| Inches | Class of work |
|---|---|
| 8½ × 11 | Lists and sketches. |
| 12 × 18 | Small details. |
| 18 × 24 | General details and small assemblies. |
| 24 × 36 | Assemblies, foundation plans, large details. |
| 48 × 36 | Large assemblies (folded to 24 × 36). |

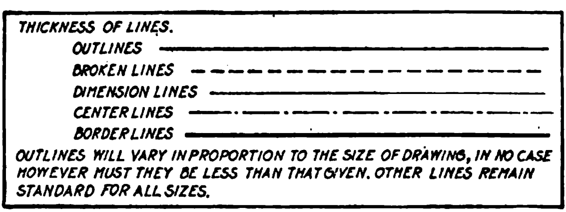



Fig. 6.

The size of sheet is to be chosen so that dimensions will be distinct and not crowded together.

3. A margin of ½ inch is to be drawn on each sheet, inside the dimensions given.
4. Standard scales only must be used. These to be ¾, 1½, 3, and 6

inches to the foot, and full size, unless other scales are ordered by the chief draftsman.

5. One part only must be shown on a sheet.

6. The amount of detail shown should be sufficient to convey a definite knowledge to the shop of what is required. More than this is unnecessary.

7. Where two hands are required, show views of both.

8. Thickness of lines to be as shown in the figure. Outlines will vary in proportion to the size of drawing, in no case, however, must they be less than those given. Other lines remain standard for all sizes. (See Fig. 6.)

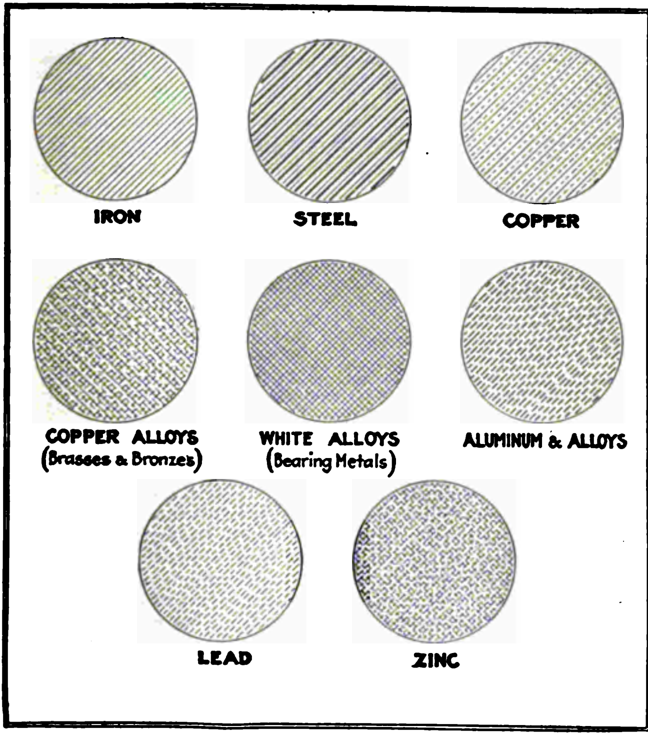



FIG. 7.

9. Dimensions are the most important part of the drawing. They must be those which will be used in the shop. Unnecessary dimensions must be omitted. In no case must it be left to the machinist to add dimensions to obtain a necessary measurement. Dimensions of angles must refer to existing surfaces. Shortest dimensions must be nearest the outline. No dimensions must be placed within spaces less than ⅜ inch wide (actual). Under this they must be referred to the space by a reference line. A dash must in all cases be placed between the foot and inch figures, thus, 2′-6″ instead of 2′6″. All dimensions under 2 feet must be expressed in inches. In these cases, inch marks to be omitted. Minimum size for dimension figures is to be, for whole numbers, ⅛ inch high, for fractions 5/64 inch.

10. Notes and letters must be written in round hand. On small sheets, under 18 × 24 inches the minimum height for small case letters to be ⅛ inch; larger size prints, the minimum to be 5/32 inch. Notes are to be placed whenever possible in a column at the right hand of the sheet, and are to be underscored and connected with the part referred to by means of free-hand light lines terminated by arrow heads. Notes must be used freely, whenever their use will help to explain matters or will avoid an additional view.

11. Notes in all cases must read in the direction that the title reads. Figures and letters must read from the bottom and right-hand margins.

12. Line shading is allowed only on assembly drawings. Surface shading only on drawings sent to customers, except in such cases where its use will save an additional view.

13. Cross-sectioning. On all detail and shop drawings, cross-section to be open in character and varying in spacing according to the size of the sheet, but in no case closer than 1/16 inch. Section lines under 1 inch long, must be drawn free hand. The name of the material to be written upon the section, using the standard abbreviations.

14. Assembly and customers' drawings to be cross-sectioned in accordance with the following standard cross-sections. (See Fig. 7.)

15. Finish marks. The symbol for finish to be a capital *F*., with its foot resting upon the line indicating the finished surface, the letter being drawn at right angles to this surface.

16. Standard abbreviations are to be as follows:

| | |
|---|---|
| Radius—Rad. | Brass castings—Brs. Cast. |
| Diameter—Dia. | Bronze castings—Brz. Cast. |
| Pitch diameter—P. Dia. | Aluminum castings—Al. Cast. |
| Outside diameter—Out. Dia. | Steel forging—St. Forg. |
| Center distance—Ct. Dis. | Steel stamping—St. Stamp. |
| Angle—$\phi$. | Pressed steel—Press. St. |
| Cast iron—I. Cast. | Sheet iron—Sheet I. |
| Malleable iron—Mal. Cast. | Sheet brass—Sheet Brs. |
| Steel castings—St. Cast. | Galvanized iron—Galv. I. |

17. Checking drawings. Designs are to be checked before tracing for: design, material, cost, strength, molding, clearance, assembling, use of standards.

Tracings are to be checked before approval for: oiling, finish, dimensions, arrow heads, pattern No., threads, pins, number of pieces, fits, limits, title, drawing No.

**30. Additional data in instructions.** In addition to instructions such as these, it is well to include specified directions for such things as making out time cards, use of drawing room indexes, methods of filing tracings, use of the data books relating to either standard product parts, to be used in new designs, Fig. 8; standard material, in stock and available, Fig. 9; method in filling in titles.

**31. Standardization of machine units.** This is a tendency of modern manufacture which will probably be extensively increased in the future. Instead of assembling the whole machine piece by piece the various units are assembled first and then these units are assembled to form a complete machine. This is known as "*Unit Assembly*," Fig. 10. The *advantages of* such a method are as follows: (*a*) It permits *detailed time study* of assembling by reducing it from a complicated operation to a series of simpler operations which are more easy to handle. (*b*) It adds to *interchangeability* with respect to various machines which often may use common units. (*c*) It permits the *quick delivery* of machines through having a great deal of the work completed in stock, but as these are not the large parts, such as frames, bases, and the like, less room is required for their storage. (*d*) It permits the more *flexible handling of assemblers*, who under former methods could not be worked on stock as-g to any great extent without tying up a great deal of money

and space. (*e*) It favors the ***development of specialists*** on assembling, which not only tends to reduce the cost but to ***insure better***

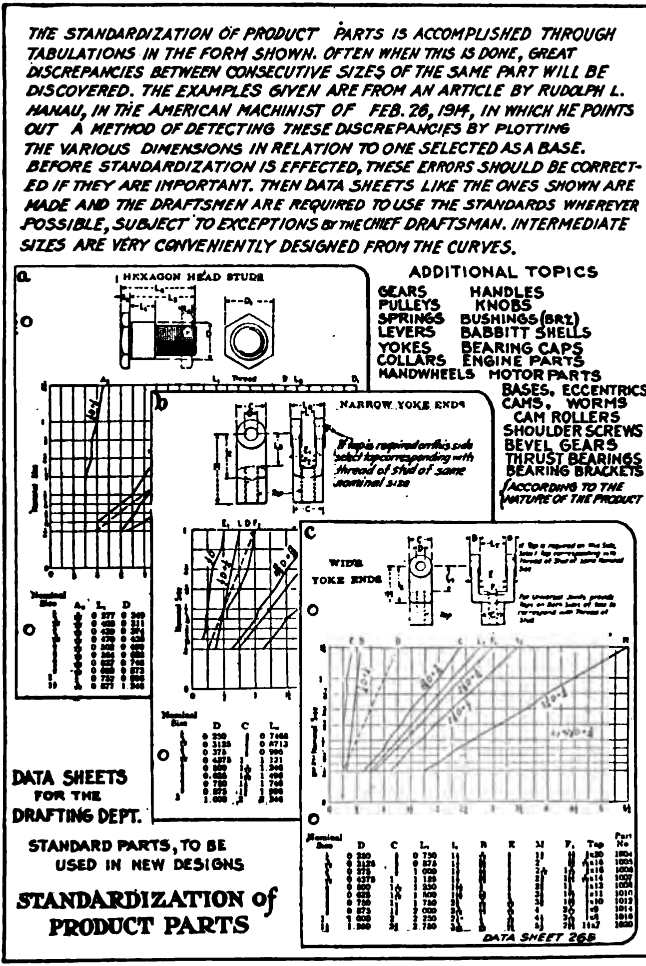



Fig. 8.

***work.*** (*f*) *It aids inspection.* Detailed inspection of a complete machine if it is at all complex is a difficult matter, and many defects in minor adjustments may easily be overlooked.

All automobile factories work on the principle of unit assembly, some going so far as to make it a point to assemble any two pieces which may be put together and return them to unit assembly stock.

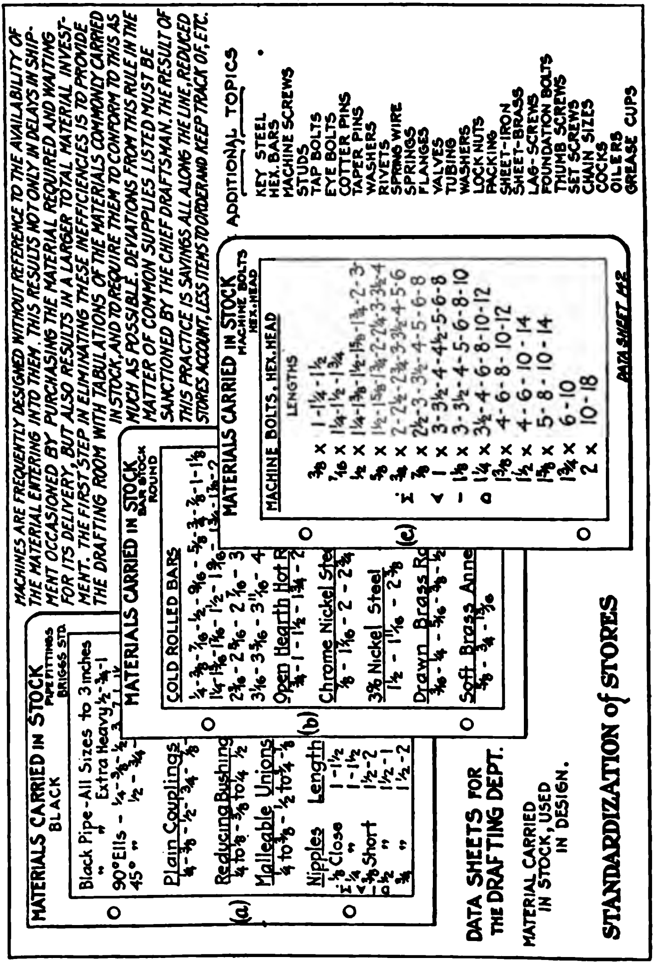



Fig. 9.

It is an *important factor in dispatching*, on the principle that the shorter we make the trip between starting and finishing point, the easier it is to time it properly.

In the small shop these methods apply equally well, although not to such a large extent. Whenever studs are set into a cylinder, or one piece is bolted onto another, or a bearing cap is fitted to a bearing, as an independent operation, we have unit assembly. And when we make this a regular proceeding, we have standardization of machine units. The principle is to assemble as little of the machine as a whole as possible, and by following it the small shop will gain through faster time, better arrangement of stock, and quicker deliveries. An example is as follows:

## UNIT ASSEMBLIES

**32. Unit assemblies comprising a high-pressure plunger pump.**

1. Frame and main bearing assembly.
   *a.* Frame, studded for bearing caps, pinion-shaft bearings, and valve chambers.
   *b.* Bearing caps, with oilers and nuts.
   *c.* Bearing liners, in halves with dowell pins.
2. Crankshaft Assembly.
   *a.* Crankshaft.
   *b.* Main gear and key. Gear pressed to shaft.
3. Plunger and Rod Assembly.
   *a.* Plunger.
   *b.* Plunger pin. (Also screws to hold pin to plunger.)
   *c.* Connecting-rod. Studded for cap.
   *d.* Rod bushing for pin. With oiler.
   *e.* Upper end cap. With nuts and oiler.
   *f.* Upper end bushing. Split and dowelled.

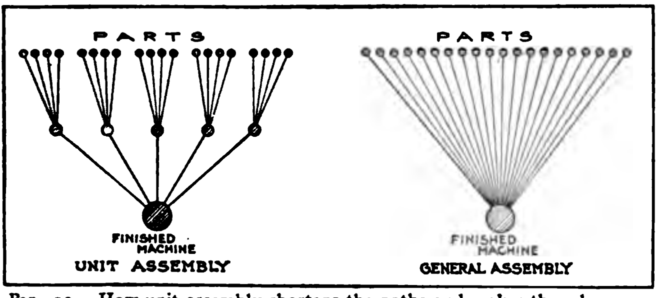



FIG. 10.—How unit assembly shortens the paths and makes them less confusing.

4. Pinion Shaft Assembly.
   *a.* Pinion shaft.
   *b.* Pinion and key. Pinion pressed to shaft.
5. Pinion Shaft Box Assembly.
   *a.* Bearing brackets (lower half bearings) studded for caps.
   *b.* Caps. With oilers and nuts.
   The above bearings and caps babbitted and reamed, ready for scraping.
6. Suction Valve Chamber Assembly.
   *a.* Valve chamber casting, studded for covers.
   *b.* Valve covers. With nuts.
   *c.* Valve seats.
   *d.* Valve plates.
   *e.* Valve springs.
   *f.* Valve disks.

7. Discharge Valve Chamber Assembly.
   a. Valve chamber studded for covers.
   b. Valve covers with nuts.
   c. Valve seats.
   d. Valve plates.
   e. Valve springs.
   f. Valve disks.
8. Miscellaneous Parts.
   Air Chamber.
   Suction Flange.
   Discharge.

**33. Unit assembly drawings and lists.** To conform to the principle of unit assembly, the drafting department in a plant where this is practised subdivides its assembly drawings and lists also. Thus, *each unit* being regarded as an independent complete assembly *has its list of parts*, from which the necessary information is obtained by the department concerned without the necessity of picking it out of a mass of other data having no relation to it. These lists are identical with the bills of material described for complete machines, but contain reference to parts entering the unit only. Taken together, the lists for all unit assemblies on a given machine constitute the machine. A master list refers to the various unit lists, as indicated below:

**Master List No. 522**

Constant Speed Universal Miller No. 4

| Designed, 6–28–12 | Drawing No. | List No. |
|---|---|---|
| General assembly | 6–248 | .... |
| Countershaft | 8– 21 | B– 1 |
| Clutch pulley | 17– 56 | B– 2 |
| Speed box | 4– 65 | B– 3 |
| Feed box | 2–124 | B– 4 |
| Knee | 3– 32 | B– 7 |
| Saddle and carriage | 4– 27 | B– 8 |
| Table | 4– 28 | B– 9 |
| Spindle and bearings | 1–149 | B–10 |
| Drive shaft | 12–213 | B–11 |
| Table | 7– 18 | B–12 |
| Frame and over-arm | 7– 56 | B–13 |
| Dividing head | 11– 14 | B–14 |
| Tailstock | 3– 56 | B–15 |

**34. Committee work on new designs.** One point to the disadvantage of the large plant in comparison with the small one is the closeness of touch which usually exists in the latter. A new design in the small factory would probably combine the best that the president, designer, foreman and often the workman could give it. There is a sense of exclusiveness in many large plants which is like the lack of neighborliness in a large city, and too many times a new design is first seen or heard of in the shop when the drawings are sent down for use.

**35.** To secure the *advantages* of the *all-round point of view* and to forestall difficulties in advance is the function of the *design committee* which is found in some large plants. It consists of the designer, chief draftsman, sales manager, superintendent, the foreman or foremen of the machining and assembling departments, and any others who are thought to have ideas of value on the subject. A preliminary design is usually presented for their consideration so as to provide a basis for comment, and the details are

gone into one at a time from the various phases of operation, construction, cost and the like. The result of this is that, when the design in detail is made and sent into the shop, it is as nearly right as the combined intelligence of the different men can make it, and a great deal nearer to being "all right" than if it were the product of one mind alone. This also has the advantage, less measurable in dollars and cents, of forestalling the criticisms of the chronic kicker whom we often find, who can always suggest a better way to make things. In this case he has the opportunity of relieving his mind on the subject before it is in final form, and if his suggestions are of value they are incorporated.

**36.** Another subject which may well be considered by a committee of this sort is that of *design changes for the purpose of cost reduction.* The shop through its intimate experience in handling a piece of work often sees opportunities to do it to better advantage if some change were made in its form. When this is suggested to the designer, the combination of pride and obstinacy quite often occasions feasible changes to be neglected. The shop foreman may grumble and probably will, but not being a squealer the matter is allowed to drop and the interests of the firm suffer in consequence. If matters of this kind are taken up in committee meeting at which an unbiased official, as the general manager should be, is present, desirable changes will undoubtedly be made. And the shoe is not always on the one foot, for the designer may often suggest a better method of machining than the one which is in common use in the shop.

**37. Standardization of detail in machine tools.** This is something that is not done to any large extent by the builders of machine tools, and this makes it necessary for the purchaser to do it if it is done at all. There is no reason, for example, why machines of the same relative type and capacity should not be provided with tool-holding devices corresponding in size, or with similar threads on the spindle noses, and so on. If these features were more standard there would be a greater interchangeability in the matter of small equipment within the plant. It is not a difficult matter to change tool posts with this end in view, nor to provide screw bushings for the spindle noses of various lathes so that chucks may be used interchangeably. Sometimes these small details can be standardized within the factory at an expense which will soon be made up by the decreased total amount which has to be invested in minor equipment. (See pp. 105 to 139.)

**38. Standardization of jig and fixture parts.** The tool room is often regarded in the light of a place exempt from all ordinary requirements in the nature of getting out the product at a minimum cost. While we do not wish to destroy the prevailing standard of accuracy that exists in this department, or reduce the quality of output, there are certain steps which may be followed to make it a more efficient and a less expensive proposition. It will help in understanding this to review the various ways in which tool rooms are commonly conducted. One that prevails extensively, and possibly the worst, is that in which one man is given a jig or tool to complete from start to finish. He will plane the finished surfaces

in the tool-room shaper, then drill for the hinge pins and fit the hinge cover, then lay out his holes and bore them, cut the stock for the bushings on a hacksaw and turn them on a lathe, afterward grinding them. If we allowed that method in the shop,

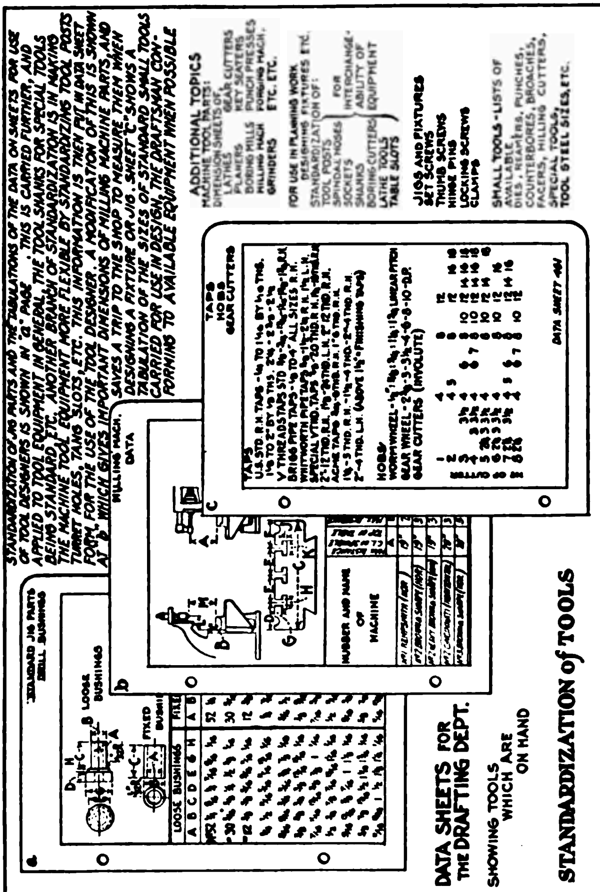



FIG. 11.

even with work requiring the utmost accuracy, the company would soon be in the hands of a receiver.

A second method, and a little better, is where the *functions are divided between machine hands and toolmakers* who do the fitting and assembling. There is no doubt but that the machine work in

such cases while done at a faster rate is done equally well if not better.

A third step, and a still more desirable one is to still further divide the work according to the degree of skill required. The rough work may be done to advantage outside of the tool room by those who are more trained to appreciate the value of time. The tool maker's skill is applied only where it is needed, and this is further subdivided, one man doing the locating and laying out, another the fitting, another the testing of the first piece and another putting the final finishing touches.

To do this to the best advantage requires the standardization of jig parts. There is no valid reason why jig screws for example have to be different for each jig made, or cannot be produced in lots by one of the manufacturing departments and held in stock in the tool room. Nor is there any reason why jig bushings cannot be standardized, made on the screw machine in lots of a hundred or so and similarly held in stock. The final grinding or lapping may be done in the tool room if the degree of accuracy requires it. Jig straps should be standard, hinge pins should be standard, and the more of these parts we make in this manner, the less will be the tool room's share in piling up the overhead. The *use of data sheets* as illustrated in Fig. 11 is a necessary step in this direction.

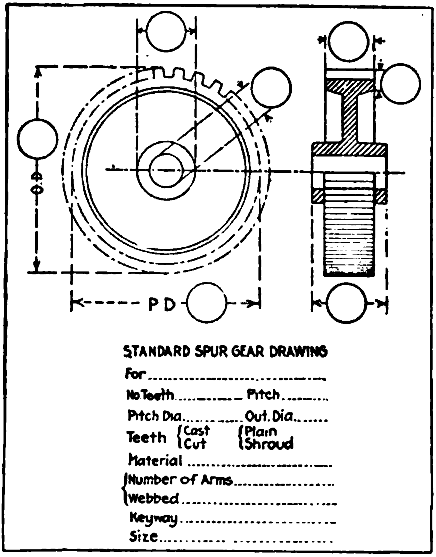



FIG. 12.—Interchangeable drawings for standard or frequently used parts.

**39. Standard interchangeable drawings for machine parts.** It is sometimes a convenience to keep on hand finished prints with blank dimension spaces for standard machine parts which are likely to be ordered in a hurry on account of breakdown or other reasons. As shown in Fig. 12, one print is often all that is required to cover a large line. Almost any size gear, for example, could be represented on the figure shown. The same thing applies to many other standard parts, such as worms and worm-wheels, bevel gears, collars, shafts, handwheels and the like. There

are standard prints which are offered on the market at a nominal sum, reproduced on the printing press, and covering a large line of such details. Their use is likely to save expense as well as delays. These drawings may be made in the form of tracings, circles or squares being left blank for dimensions and made opaque with india ink or pasted paper so that they will print white.

## FILING METHODS

**40. Filing tracings and lists.** Tracings are filed in several ways. A good method is to file them in steel drawers within a fireproof vault. Drawers are provided with some means to keep the tracings flat and compressed, so that too much room will not be taken. Spring clips, weights, and flat sheets of glass covering the tracings are among the methods used, the latter being especially good as it helps protect the tracings from dust and puts an even pressure over the surface.

**41.** Sometimes tracings are rolled and filed in metal tubes. These tubes are then placed in a vault. There are a number of disadvantages to this scheme, chief among which is the damage to the tracing caused by rolling and unrolling. It is the only feasible way, however, to file exceptionally long tracings without folding. The contents symbols are indicated on the covers of the tubes. A somewhat similar scheme is one used abroad where round tiles imbedded in concrete and provided with metal covers take the place of the metal tubes.

**42.** Vertical files are sometimes used. The only apparent advantage of this method is that the sheets are removed and replaced with equal ease, whereas in the horizontal drawer, difficulty is experienced sometimes in getting out and replacing bottom sheets without disturbing the rest. A modification of the vertical file is the hanging portfolio, in which tracings are placed in a suspended affair resembling a large book cover.

**43.** Aside from the mechanical filing of tracings, is the method of filing them with respect to nature and size of the drawing, assembly, and so on. Good practice is to file them according to size of sheet, regardless of connection; the file location as indicated on the list being sufficient to locate them. When this is done, the drawing number is made up of the drawer number and the sheet number, separated by a dash. The sheet number is the relative location within the drawer, starting with sheet 1 on the bottom.

**44.** Another common way to file tracings is to keep *all drawings of a given assembly together*, regardless of size. This is used with the tube and portfolio systems. The location is given by the name or symbol of the assembly. A great deal more room is required when this plan is used, since a small letter-size tracing takes as much space as a complete layout, unless the latter be folded, which is bad for the tracing. The only advantage which can be claimed for this method is having all tracings which relate to a given machine at hand in one place. Blue-books, however, answer the purpose as well and save handling the tracings.

**45. Lists, or bills of material** are filed in various ways. Where drawer scheme of filing tracings is used, uniformity argues in

favor of filing lists in this manner also, and designating them by drawer and location number. Where the portfolio scheme is used the list is usually filed with the tracings. In other places, lists are sometimes filed in loose-leaf binders and have numbers independent of the tracings. These numbers may be serial numbers, or machine symbols, the location within the binder being according to the serial number or symbol.

Sketches are often filed in copy books, being located by the page number, a cross-index being made by subjects, referring to this page number. When the drawer system is used, a better plan is to keep all of the filing uniform in character, including the sketches, tool and jig drawings, lists and the like. Letters may be used to designate the drawers if this is desired, or distinction made between sketches, tool drawings, production drawings and the like, by various cabinet symbols. Since separate sections are usually kept for these various types of sheets, however, this only adds unnecessary detail, the drawer number being a sufficient indication. Fig. 5 shows a drawing cabinet layout, the cabinets being on the sectional plan and drawer numbers assigned to leave room for expansion.

Whatever filing scheme is used, when a tracing is withdrawn, the user should substitute a sheet of paper in its place, stating who has it. Otherwise much time may be spent hunting for a supposedly misplaced tracing. Large drawing rooms employ a clerk to keep a record of all tracings out.

**46. Method of issuing and filing blueprints.** In plants where fireproof storage for tracings is not available, it is sometimes a precautionary measure to have a print of each drawing made and filed in some location independent of the building containing the tracings. In this case, care must be taken that the prints are kept up-to-date.

**47. Methods of issuing prints to the shop** are as follows: On standard drawings, for use at machines, prints are usually mounted for the convenience of the operator. The materials on which they are mounted are numerous, among them, cloth, leatherboard, wood, fiber, cardboard, and sheet iron. The latter ranges from 18 to 24 Ga. according to the size of the print. The prints are also coated with shellac or varnish so that they will not become soiled. Mounted drawings are usually filed in the shop, sometimes in the production office, and sometimes in the tool crib, in the latter case being issued on checks, like tools. They are recalled only when superseded or changed, but for this purpose a record must be kept in the drafting room showing where they are located.

**48. Books of complete machines** are often issued, usually to the assembling and cost departments. A set is kept in the drawing room to avoid handling tracings in looking up dimensions and other data. These books may be either complete in one volume, as is customary when the number of sheets involved is not large, the small sheets being placed on top of the big ones; or they may consist of several volumes arranged according to sheet size. A list or bill of material is usually bound with the prints of each complete machine. Oil-cloth covers are provided to prevent tearing and soiling.

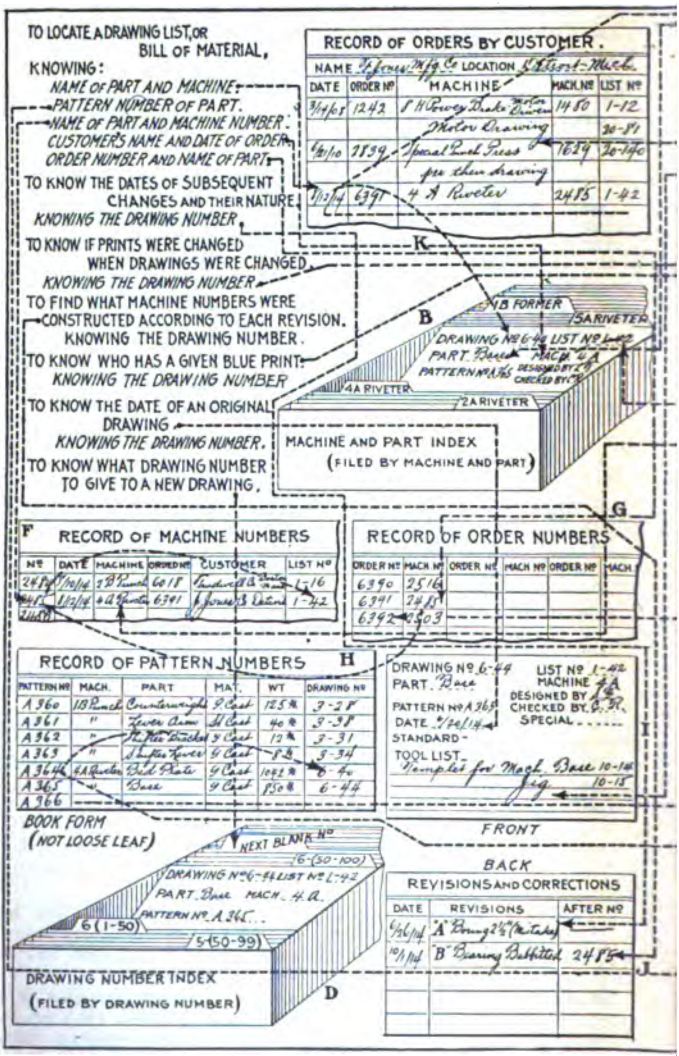
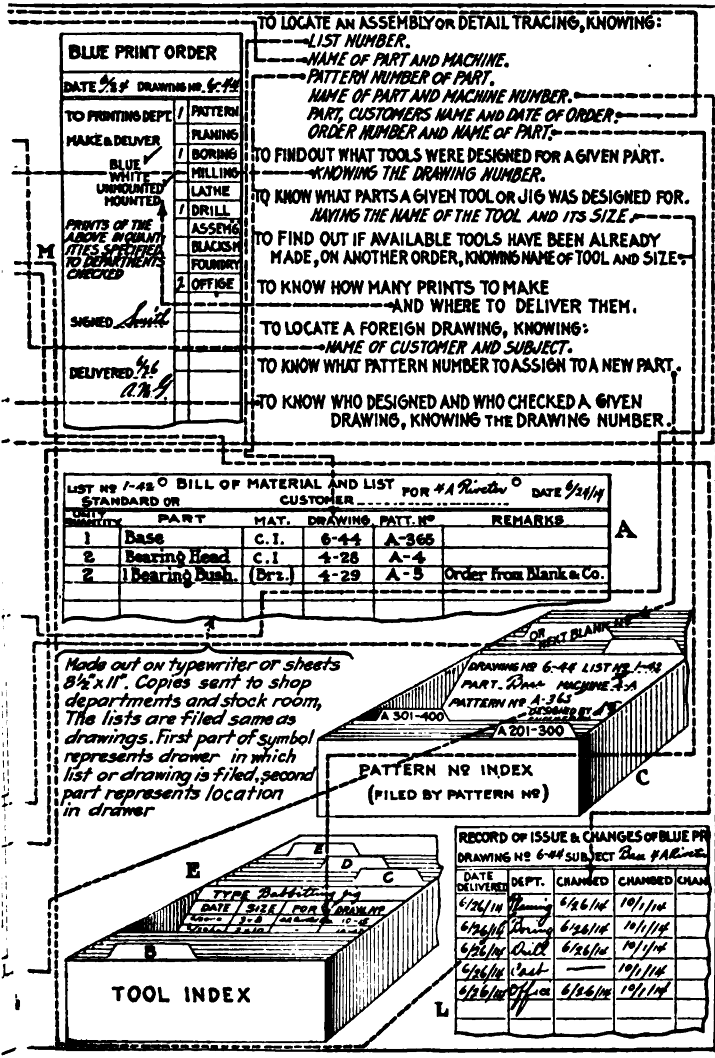



Fig. 16.—System of




records for drafting room.

being all made at once, preferably on the typewriter. They are filed in different file boxes, each being arranged according to the subject indexed. The principal labor is therefore in filing the different copies, since it takes but little longer to make out several than one. Additional information may be added to any one of these files, as for example, the record of tools as shown at *I*, and the record of revisions as shown at *J*. Suggested subjects for filing these key cards are as follows: by drawing number; machine and part; pattern number; shop symbol.

**59. Record of pattern numbers in book form.** In addition to the key-card record of pattern numbers, which is largely for shop use, it is advisable to have a more permanent record in book form, as shown at *H*, Fig. 16. Where patterns are numbered consecutively, as made, this is preferably a solid bound book, so that pages cannot be mislaid. Among the subjects which may be given to advantage in this book are: pattern number; machine; part; date designed; pattern location (unless keyed by pattern number); material; weight of casting (average); drawing number.

**60. Record of machine numbers.** Where machines are given shop numbers, which is usually done consecutively, a book record of these numbers should be kept, preferably in solid binding. This record can refer to machine number, date of order, machine, size and type, order No., customer's list No. (See Fig. 16 *F*.)

**61. Record of customers' names and order numbers.** It is often necessary to locate information having the customer's name, especially in furnishing repair parts where indefinite information is furnished. To facilitate this the above record is kept, in loose-leaf form, arranged alphabetically by customer's name. The following points should be noted on this form: Customer's name; date; machine, type and size; machine No.; list No. (See Fig. 16 *K*.)

**62. Record of foreign drawings.** Foreign drawings usually come in connection with a special order, and the customer's name is known. The record of customers' names and order numbers is therefore the logical place to state the file location of these drawings. (See Fig. 16 *K*.)

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NOTE TO FIG. 16.

Economy in the drafting room necessitates the finding of desired information with the least expenditure of time and energy. This chart shows the numerous questions that have to be answered, and the records which will answer them. The fundamental point is to arrange matters so that the tracings will not be handled except for printing purposes, as otherwise they quickly become defaced. All information therefore must be secured other than from the tracing itself. Twelve sets of records are necessary to give this information quickly and efficiently. Three of the forms however *B*, *C*, and *D*, are identical, being made at once but filed differently.

Under the system represented, the location of lists, drawings, and tool and jig sketches determines the list number, drawing number and tool number, the first figure of the symbol representing the drawer in which the drawings are filed, and the second the sheet location in the drawer. This same scheme is sometimes applied to pattern numbers, resulting in simplification where this is possible.

No matter what forms of records are kept, the information indicated must be obtained. The graphical representation of how this is done is a great aid in familiarizing new men with the methods in vogue.

**63. Record of order numbers** is preferably kept in a solid bound-book form, as shown at *G*, Fig. 16. For simplicity it will be sufficient to refer on this form to the machine number only, since other data will be available from this.

**64 Order for designs.** A simple form should be used to indicate who is the authority for ordering a new design. In this connection, sufficient information is often placed upon such an order to give the designer a working start. In the government shipyards, planners are employed to investigate jobs which require drawings. These men have the skill and experience which enables them to write definite working instructions to those who are to make the drawing. In this way experience is made available among a large number who are thereby enabled to produce a higher grade of work than if left to themselves, or the occasional instructions of a chief-draftsman.

## CHANGES

**65. Keeping track of changes.** Changes in design are extremely important to record, as otherwise shop practice and recorded design will draw gradually apart, leaving an opening for much confusion and error, especially in the matter of repair parts, which are likely to be ordered without much thought as to their proper designation, or the aid of a sketch.

Of prime importance, to avoid this, is the necessity of laying down a hard and fast rule that *no changes are to be made unless authorized by the drawing room.*

On the other hand, too much opposition to a change for the better will have the effect of killing all tendency toward improvement suggestions, and since many of these come from the shop after the theory of the drawing is reduced to definite practice, a condition of this kind must not be allowed to occur. A definite procedure for handling changes is therefore desirable. In some plants, those who are in position to request changes are provided with padded books for that purpose, retaining a copy of the suggestion. These are then considered by a committee consisting of the management of the plant, the chief engineer, chief draftsman, the superintendent and any others whose advice on the subject is of value. In this way the matter is pretty sure to be threshed out thoroughly and changes which are not important will probably be passed over, since they tend to disturb standardization. A system of this kind maintains automatically what has been termed the *progressive standard*, since changes of small importance are not likely to be made under it and those which are made will advance the standard.

**66.** Changes which are slight, such as the correction of dimensions, and the like, do not require a new tracing. They are properly cared for by means of space allowed for this purpose on the tracing and a record of the drawing numbers changed which is filed by the drawing number, giving the following information: Sheet No.; item changed; date; reason; authority; executed by; last machine built with this construction. If this record is on card form, say 4 × 6 inch size, it may well serve the

additional purpose of an order to make the change. Fig. 17 indicates a convenient way of noting changes on the tracing. Space for this purpose is allowed next to the title-space and reserved for this purpose. Small changes are given key letters which locate them on the record space, as to date.

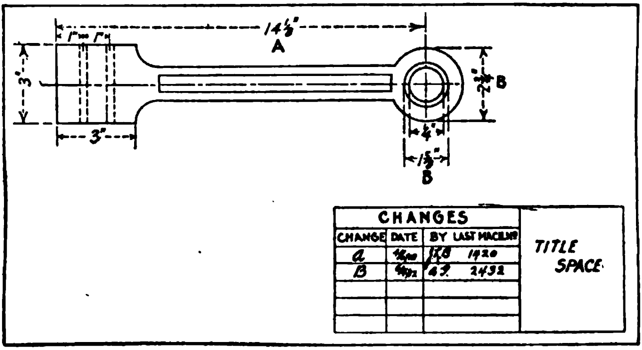



Fig. 17.—Method of recording changes on tracings.

**67.** Where the change is so great as to require new tracings, other methods must be employed. The superseded tracing is usually marked with cross lines of coarse pitch, so that there will be no mistake about its being an old one. The words *superseded by* are printed in the change column, followed by the number of the new tracing, and the date. It is a good plan also to state the shop number of the last machine made according to this drawing. The new tracing is marked, *superseding*, followed by the drawing number of the old tracing, and the date. It is also a good plan to note upon it, "*After Machine No.*," so that this information appears on both old and new prints.

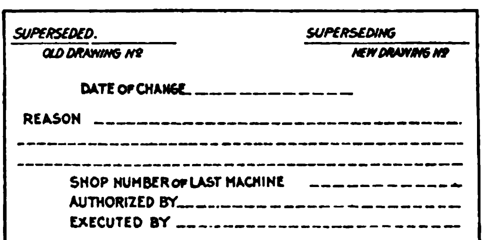



Fig. 18.—A card index of changes.

**68.** In addition to the notations made on the tracings, it is well to have a card index to cover this point, so that the tracings will not have to be handled. Such an index card is shown in Fig.

18. It is made out in duplicate and filed both according to superseding number, and according to superseded number.

**69. Keeping track of changes on blueprints.** The form shown at *L*, Fig. 16, is a convenient one for this purpose. It not only provides space for noting the dates of several changes to each print issued, but also gives the location of the prints, which is of service to the man who makes the changes. When a drawing is entirely replaced by a superseding one, all copies are recalled and the record sheet destroyed, a new one being made out for the new drawing. These record sheets are filed by drawing number, and may be either of card or book form.

**70. Rectifying mistakes in drawings.** A mistake in a drawing is sometimes discovered, and becomes a point of knowledge to the foreman and some mechanics, to be corrected by them when occasion requires with the next occurrence of the same work. The drawing is not corrected, but all goes well until the work is given to a new man in which case it is quite likely to be spoiled. To obviate the chance of this, definite means must be provided whereby tracings, and prints as well, are immediately changed as soon as an error is discovered.

If this is not done, after a period of time the drawings and the actual work become further and further separated, and the burden of special information becomes so great that it is impossible to avoid costly errors. When a new machine is completed, after the various transitory changes have been made it is a good plan to send a draftsman down to check up his prints in detail with the construction as it stands, on the same principle that it is advisable to take a physical inventory of materials on hand periodically to correct errors in the running accounts.

## FINISH, LIMITS AND CHECKING

**71. Unnecessary versus sufficient detail on drawings.** The amount of unnecessary time spent in the drafting room can be judged from a close inspection of almost any shop blueprint. The following, Fig. 19, shows how time may be saved without the sacrifice of clearness. Fine shading should not be allowed, nor, to any extent, should we permit the designation of material by so-called "conventional" or "standard" cross-sections, as it is easier to use plain coarse cross-sectioning, and write the name of the material on this section. There is also no reason why bolts, studs, cap-screws, set-screws or washers should be shown, as the center line and a note giving the sizes is enough to convey a clear impression of what is wanted to any one who has mechanical experience enough to use a drawing at all. In fact, leaving these unnecessary refinements off makes the important part of the drawing much clearer. *Notes on drawings* are easy to make and will often save an additional view or many lines. Some draftsmen seem to consider it a disgrace to use notes in this connection regardless of the fact that it economizes time wonderfully. Notes should be written instead of printed, for it is much faster and if done in a round open hand will be more easily read than a great deal of the fancy lettering. Center lines for pitch diameters, and plain circles

for outside diameters of gears will convey sufficient information to any one who knows what a gear is, and a close delineation of the teeth on the drawing will not make the finished article run any smoother. It is also an unnecessary refinement to show the arms of gears or pulleys in drawings for the shop, as the machinist has nothing to do with them, and for purposes of identification,

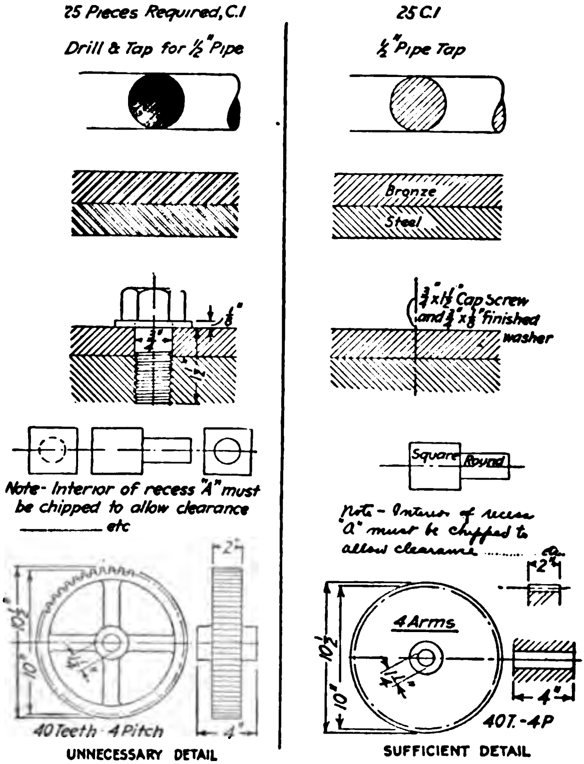



FIG. 19.—Necessary and unnecessary detail.

notes stating the number of arms, or a solid web, are as good as the picture. In addition to the foregoing, all figures should be made large enough to be easily seen in a dark shop, the lines of the drawing should be coarse and legible, dimensions should be put in places which will be most convenient for the workmen, and should be such that it will not require the addition of fractions to arrive at a necessary dimension.

**72. Placing limits on drawings.** In defining the degree of accuracy, there are several schemes in present use. One simple one is to indicate by the dimension figure the degree of accuracy required. Thus, $7\frac{16}{32}$ inches would indicate that the $7\frac{1}{2}$-inch dimension was to be finished to within $\frac{1}{32}$ inch; 4.50 inches would indicate a $4\frac{1}{2}$-inch diameter with a tolerance of 0.01 inch either way; 4.250 inches would mean a tolerance of 0.001 inch on either side. Where tolerances are more than one unit of the last decimal place the only solution seems to be to give the plus and minus, as: $4.250''\begin{smallmatrix}+0.002\\-0.002\end{smallmatrix}$ or $4.250'' \pm 0.002$.

Where tolerances differ as to upper and lower limits, $4.250''\begin{smallmatrix}+0.001\\-0.003\end{smallmatrix}$

Where the given dimension must not be exceeded, but tolerance is allowed below

$$\frac{4.250''}{4.247}$$

**73. Where limit gages are used exclusively** it will not be necessary to place the numerical tolerance on the drawing, but to refer to the number of the limit gage which is used. This is a definite way of stating the degree of accuracy required which is readily understood by machine hands who never handled or saw a micrometer.

**74. Indicating the degree of finish.** When a mechanic is working from an individual print, and has not seen an assembly drawing, and does not know in what connection the part he is making is used, he has no idea as to the requirements of accuracy and finish unless these are plainly stated on the drawing. The result is that he will generally put too much time on the piece and give it the best finish possible. This is a clear loss of money, especially in cases of parts that have no particular need for accuracy, and where the finish will not matter because they are not visible.

When this matter is put up to the draftsman, it is not helped to a great extent, for unless he has had considerable mechanical experience, he dislikes to commit himself on the subject. Consequently on the majority of blueprints, the matter is ignored altogether and left to the shop to decide.

The *proper individuals to state how much finish* is required and what degrees of accuracy are the *chief draftsman* and the *designer*. This is also a very good opportunity to make use of Committee Work. (See 34 to 36.) But it is as necessary and important to have this information on the drawings as it is to have the dimensions. The next question is as to how it shall be indicated. This divides itself into two problems, first, showing the accuracy required, and second, showing the finish required. The two do not go together, for some parts that do not matter if they are within a sixteenth of an inch in size require to have a fine polish for appearance sake.

**75.** Each shop should choose a definite and graduated scale of finishes, varying from a rough cut to a high polish. Samples of what is meant by each may be made available in various depart-

ments to familiarize new hands with what is meant by *Finish No. 1* or *Finish No. 4*. A suggested scale is as follows:

No. 1 Rough cut finish.
No. 2 Light cut with round nose.
No. 3 Finish Cut.
No. 4 File Finish.
No. 5 Light Polish.
No. 6 High Polish.
No. 7 Scrape.
No. 8 Spot.

These numbers may be placed upon the drawing after the finish marks and will leave no question as to what is required. They are also of great use to inspectors in deciding whether the finish of a part is passable, this being something that is usually left more to personal judgment than anything. Judging a piece for finish under this plan becomes as easy as determining whether it is within proper limits. Samples of this kind are very conveniently mounted in cases which are provided with glass fronts to prevent their becoming handled and rusted.

**76. Use of assembly drawings.** Assembly drawings serve a variety of purposes both in the drafting room and in the shop. In the drafting room, design is often started by laying out the assembly first. It is often checked for proper clearance and dimensions by combining the details as drawn into an assembly or construction drawing which shows their relation to each other. When design is started with an assembly drawing, this must naturally be modified with the changes that develop when detailing the various parts. It is a good plan with an operative machine that is at all complicated to make a final assembly from the details independent of the original assembly, and in addition to it. Many errors are discovered in this way, which is somewhat cheaper than finding out that parts do not fit after they are machined.

Assembly drawings in the shop serve the purpose of showing how the parts are put together and their relationship. They are quite essential on new work with which the men are unfamiliar.

Still another purpose is served by the assembly drawing, and that is to give the customer an idea of what he is getting, or to point out structural advantages to the prospective customer. For this reason assembly drawings are finished with more elaboration and with an eye toward effective appearance than are the detail drawings which rarely get outside of the shop. Conventional shadings for sections, and surface shadings are quite permissible on these drawings when considered from the point of view of their impression on the customer.

**77. Use of detailed drawings.** Detailed individual drawings of each part on a separate sheet are coming to be used more and more in repetitive manufacture. There is no more reason in providing a mechanic with unnecessary drawings than in handing him a number of unnecessary tools in addition to the one that he requires for the work. A single drawing is easier to follow through, and the shape and size of it seems to be more clearly impressed upon the mind than when the attention is distracted by a number of other parts drawn upon the same sheet. There is also an advantage

at the starting point, the drafting room, in that the draftsman will unconsciously pay more attention to putting in all the necessary detail, dimensions, etc., than if he has many items on one sheet. Another advantage is that many men may work on different parts of the same order at the same time without the necessity of duplicating blueprints or tearing one into pieces to divide up as is often done.

**78.** In cases where it is thought undesirable to have the draftsman finish each separate piece individually, possibly on the ground that he will have to change operations too frequently to make good time, as from pencil drawing to tracing, this difficulty may be met by dividing a large standard sheet into squares which are ruled with dividing lines, putting the detailed drawing of one part in each square, and then having them cut on the dividing lines after the blueprint is made. Where the drawer and sheet number system of drawing numbering is employed, as described in (28), letters, *a*, *b*, *c*, *d*, may be used after the sheet number to locate the part on the tracing when this is done.

**79. Use of samples instead of drawings.** In some plants, sample pieces are used instead of drawings, to convey the meaning of what is wanted. The use of these is to be condemned unless the grade of intelligence employed is so low that neither language nor drawings can convey the impression of what is wanted. The disadvantages of using samples are many, among them the time required to measure each part, and which can be seen at a glance on a proper print, the fact that dimensions become incorrect through wear or abuse, and that the samples are frequently lost if placed in the operator's hands, often becoming mixed with product pieces. Samples have their uses in indicating degrees of finish, as described in (75), but as a substitute for drawings, the less they are used the better.

**80. Finish of tracings by draftsmen.** There is considerable difference in practice in the matter of tracing drawings. In some plants draftsmen are not allowed to do this kind of work which is done by boys or women known as tracers. An analysis of the work will soon indicate which scheme is feasible. Where there is a constant variety of new drawings, little standardization or complicated work, it would take the draftsman as long to instruct the tracer as to do the work himself, and in addition he would have to put a great deal more detail into his pencil work. On the other hand, where the work is specialized, simple, or where there is enough of it so that it may be divided up between various tracers, each of whom has a certain kind to do, there is no question but what the work may be done as well and at less cost by using tracers. In any case, boys may be employed to draw border lines and ink in the lettering of the titles. That is, unless the firm goes one step further and buys its tracing cloth cut to standard size sheets with the border lines printed on them as well as the outline title form.

**81. Separate drawings for the pattern maker and the shop.** On the principle that the draftsman should make matters as easy for the shop as possible, some firms make a practice of pro-

viding separate drawings for the pattern maker and machining department. The general outline of the one may be traced from the

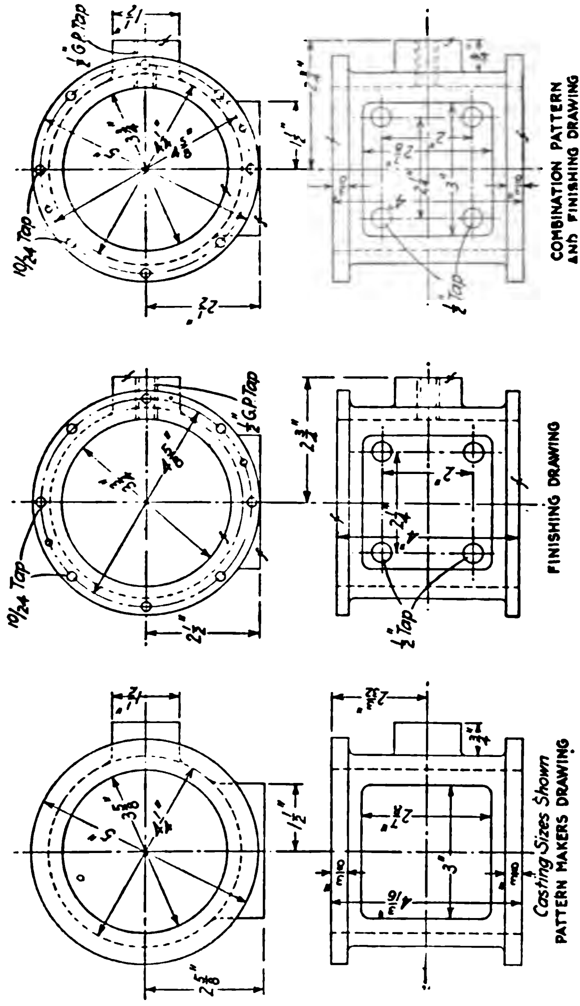



FIG. 20.—Pattern, machine and combination drawings.

other, but only those dimensions which are necessary in each case are given. A simple example of this practice is shown in Fig.

20, which also shows how much more confusing it is when the two are combined. More complicated work of course holds out even stronger arguments for this practice. It is not so much the time saved in the pattern shop that counts, as this work is done but once, but it is repeated many times in the shop and unnecessary dimensions only distract the machinist from the essential ones and lead to mistakes.

Another method which requires less work is to omit inking in those dimensions on the tracing that pertain to the pattern maker, but to go over them with a soft pencil so that they will print. Two or three prints are made from the tracing thus prepared, after which the pencil lines are erased with gasoline, leaving only those dimensions of interest to the shop. One of the blueprints is filed in the drawing room to use in case pattern changes are to be made. This is a very logical scheme, since the pattern maker uses a drawing but once as a rule whereas it is used many times in the shop.

Still another plan is to make the drawing and tracing as if it were intended solely for machining, and indicate pattern makers dimensions and details on the blueprint in yellow crayon.

*A plan sometimes adopted* is to make use of a folded tracing, whereby the pattern dimensions and details become superimposed upon the machining part of the drawing when making a print for the pattern shop. A print made with tracing unfolded gives simply the finishing detail. This means gives a simple drawing for the machinist, who uses it most, and a complicated one for the pattern maker, as do the last two plans described. They are less costly methods than the first described and illustrated, of making separate tracings for both departments.

**82. This same principle** is followed to advantage in dealing with rough and finished forging drawings. The drawing which is sent to the blacksmith shop contains the dimensions of the forging required and saves the time necessary to figure how much finish to allow in making the forging. One step further is to indicate the diameter and length of stock which is to be used by the blacksmith from which to hammer and draw down the forging. This is usually estimated by the blacksmith and may result in excessive waste of stock, as he will be careful to get the original piece big enough in any event. After it is once determined, good management would indicate making it a matter of record to save this possible waste and also the blacksmith's time in estimating.

**83. Photographs instead of drawings.** The Holt Mfg. Co. of California have a unique method of imparting information to the shop by means of photographs instead of drawings. The photo representing a given part shows all the necessary views which would be given on a blueprint, and has the dimension lines added afterward. Plentiful use of notes helps to explain what is wanted. Prints are distributed to the pattern shop, superintendent's office, drafting department, pattern storage, machine shop and branch offices. *The prints are filed in card cabinets.* Fig. 21 shows the method of filing, and Fig. 22 shows an index or list of classified photos, by means of which any desired one is easily located.

Of course new designs cannot be photographed before they are

made, so rough sketches are constructed for use by the pattern department. After the castings are made they are photographed in the rough state, and the finishing dimensions added.

The advantages offered by a system of this kind appear to be a saving of time and a decrease in the number of draftsmen required.

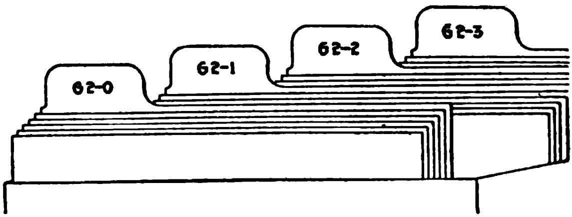



FIG. 21.—Classification of photographs in drawer.

In fact the chief and practically only duty of the draftsmen will be in laying out new designs, and placing dimensions on old ones. The process of making the photographs, which is done with a vertical camera, is not a difficult one.

**84. Use of typewriter in the drafting room.** The typewriter may be easily adapted to the drafting department. One common use is for filling out the notations on the bills of material. It takes quite a while to print these with a pen and ink, not so long to write them in a round hand, but the typewriter combines the advantages of appearance with speed. For securing good results on tracings it is necessary to place a reversed sheet of carbon paper under the tracing so that the characters are made more opaque since the typewriter ink on the face of the cloth or paper is reinforced by the carbon impression on the back, (see 51).

G. GASOLINE T. E.
GO. General Views of T. E.
G1. Motor
G1-0 MOTOR ASSEMBLED
G1-10 RADIATOR; Columns, etc
G1-11 RADIATOR FAN. Hubs, Pulleys, Gears, Brackets - etc
G2 T. E. Transmission
G2-0 GENERAL VIEWS
G2-1 FRICTION SEGMENTS
G2-2 FRICTION SLEEVES
G2-3 FRICTION SHIFTERS
(a) Clutches
(b) Turnbuckles
(c) Eyebolts
G2-7 COUNTERMAIN SPROCKETS
G2-8 MAIN WHEEL SPROCKETS etc
G2-9 COUNTERSHAFT BOXES, etc
G2-10 COUNTERSHAFT BRACKETS
G2-12 THRUST RODS
(a) Boxes (b) Nuts

FIG. 22.—Portion of list of sections of classified photographs.

Prints made from typewritten matter on onion skin paper have the clear blue and white effect of the best tracings made with india ink. The tracings must however be handled rather carefully after they are completed as otherwise the carbon will smudge. When many prints are required it is good policy to make a positive brown

print from the tracing which when printed from will give blue characters on a white ground and which will not suffer through considerable handling.

Special typewriters have been constructed to take in the large sheets used in the drafting room, and all notes on tracings made on the typewriter. All that is required is a platen of extra length which can be furnished by most typewriter concerns on special order.

**85. Keeping down the amount of pattern changes.** Patterns are often built up or changed in order to avoid the construction of new ones. Generally this is done on the initiative of the pattern foreman in order to reduce the labor in his department. It is well to help him in the matter by attention to this in the drafting room. The order for new patterns should require the O. K. of the chief draftsman, who should be particular to raise the question in all cases, as to whether this matter has been carefully considered. This is especially necessary in the case of motor, turbine or engine bases where the center line height of the driven machines is likely to vary considerably. In some instances, money is saved by having the pattern for such bases made in two parts, one of which is standard and the other subject to change. The parts are detachable but bolted together for ramming up the mold.

**86. Titles.** Elaborate hand-lettered titles are being discarded as an unnecessary item. Rubber stamps which outline the general lettering of the title common to all drawings are often used, the draftsman or tracer following these as a guide and covering them with india ink with a lettering pen. Another method is to print titles on a printing press. Still another is to use a copper or tin stencil plate and a stiff brush which is rubbed while wet against a stick of india ink, until the brush is thoroughly saturated with ink, the brush being then rubbed over the stencil plate which is laid in the required position on the tracing.

Information which must be contained in the title, but which varies with each drawing, such as name of draftsman, of piece, and so on, are usually written in round hand. The *essential information necessary* to the average title is shown as follows:

Name of company.
Name of part or machine.
Detail or assembly.
For order No.......(or standard).
Designed by.......and date.
Traced by.........and date.
Checked by.......and date.
Approved by......and date.
Drawing number.

**87. Checking drawings.** The process of checking a drawing resolves itself into two parts. The first concerns the shape of the piece—the design as it might be called, and brings up the question as to whether the shape and form shown is best for the purpose intended. The second part relates to the mechanical correctness of construction, dimensions, etc.

**88. The logical time to check** design is before the drawing is traced, since any changes resulting from an inspection for this purpose will materially change the whole drawing. Checking for

dimensions, and the like, is usually done after the tracing is completed, but before the drawing is approved.

There are several processes of marking a tracing when checking. One is to mark the corrections with a soft pencil. As these are altered, the pencil mark is erased. This however does not indicate that the drawing has been entirely checked, especially for dimensions, one or two of which may have been overlooked. To avoid this, a check mark is sometimes placed after all dimensions, right or wrong, the latter being denoted by a distinguishing mark, such as a circle enclosing the dimension.

The drawback to correcting in this manner is that after the tracing is cleaned of pencil marks, nothing remains to indicate what was found wrong, nor to place responsibility for corrections not

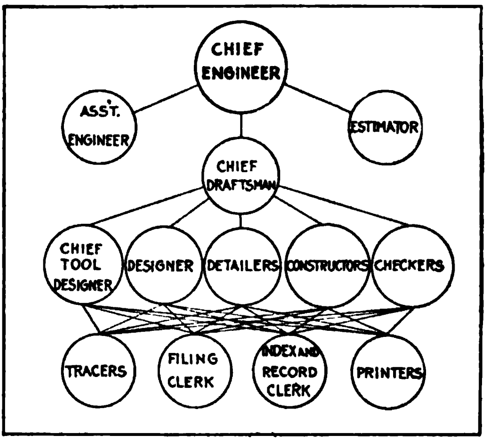



FIG. 23.—Functional organization applied to drafting room.

made. The following method avoids this. The tracing which is to be checked is printed, and the print is gone over instead of the tracing, a yellow pencil mark indicating correct dimensions and a red one wrong ones. Then the tracing is corrected from this, the print being filed away for future reference in case a mistake is found, in which case it can be determined whether the checker or the one making the changes called for was responsible for the oversight.

**89. The placing of definite responsibility** for all possible actions suggests the use of checking cards which are used by the checker, not only as a guide to the items to look for, but on which he checks each item after going over the drawing. The points mentioned in drafting-room instructions, (29) No. 17, will serve as a guide in laying out a checking slip. Since the same individual is not likely to check for both design and details, two slips are necessary. These are filed according to drawing number.

**90. Connecting the work of the product designer with the tool designer.** The method of keeping the tool designer in touch with new production designs varies according to the scheme of organization of the drawing room. In some cases, all new drawings by routine pass through the hands of the tool designer, who notes those which require tools and what tools required. This notation is passed upon by the Chief Engineer and Superintendent, in order

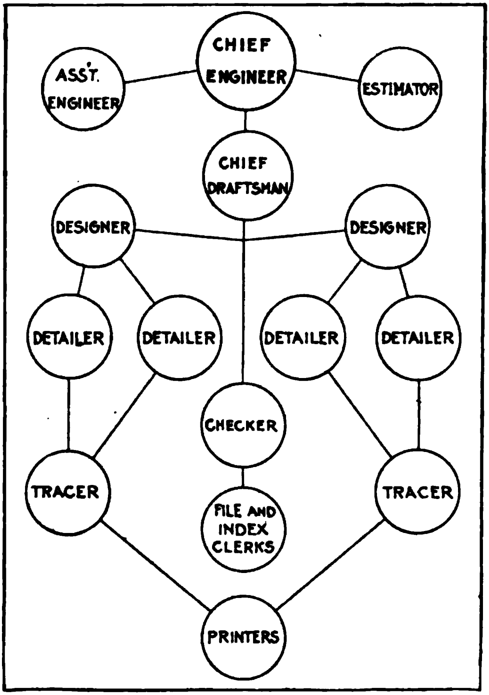



FIG. 24.—Line or "squad" organization in the drafting room.

that unnecessary investment or excessive elaborateness be avoided. In some cases the tool designer receives simply instructions as to what tools and jigs to make, having no choice in their selection. This is usually the case when the routing is done by a processing engineer who studies the most economical sequence of operations. In still other cases, the matter is taken up by a committee in connection with other details regarding the new design, as described in paragraph (35). (See Figs. 23, 24, 25.)

**91. Laying out work for the drafting room.** On an order which requires drawings before the patterns can be made, the work done

in the drafting department affects the quickness of shipment as much as that done in any part of the shop. The drafting room is therefore the first department which has to make a promise of completion on its work, and it must be said that as a rule these promises are more poorly lived up to than shop promises. At the same time planning work in the drafting room is much simpler than in the shop, since fewer elements are dealt with.

A system for laying out drafting work and estimating its date of completion is described by F. W. Harris in an article "Making and

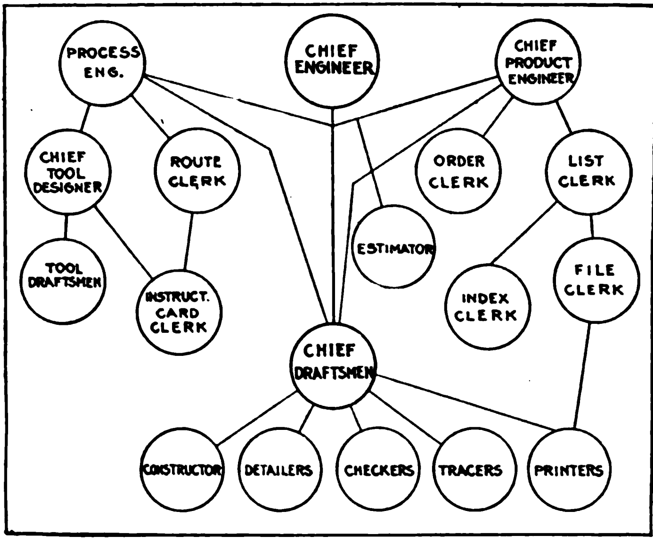



FIG. 25.—A drafting room organization designed to provide for processing and routing.

Meeting Drawing-room Promises," American Machinist, vol. 38, p. 480. On this chart, Fig. 26, the horizontal spaces represent days, the vertical ones the number of men. All jobs received are estimated in "man-days" and laid out upon this chart. Thus the date of completion of any job may be closely predicted, providing it takes its natural turn, and if it is given preferment, the effect of this on the other jobs is plainly visible.

Another plan, which is similar to keeping work ahead for machines in the production office, consists of a set of spaces, one assigned to each draftsman, in which cards are placed denoting future jobs. The Chief-draftsman manipulates these to suit conditions, and can see from inspecting his work-ahead board how the material in hand is balanced. Such slips may be used as orders to the draftsman, ...ing the necessary information, and also as time cards to ...ost of each drawing.

**92. Routing work from the drawing room.** Considerations of design vitally affect the cost of a given piece by practically dictating how it shall be machined. In view of this fact the routing of work through the shop is sometimes done from the drawing room, under the supervision of the chief engineer. This seems the logical place to handle the routing, since if it is handled in the production department there is a lack of such intimate knowledge of the functions and requirements of the piece as is or should be had in the engineering and designing department. If this department

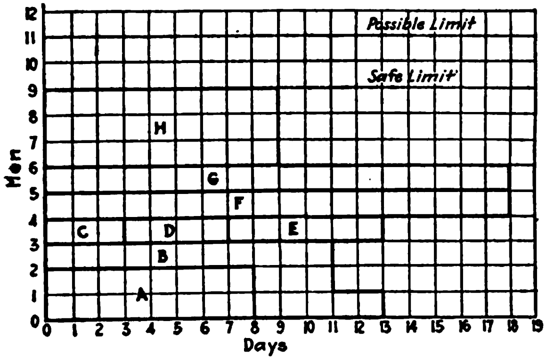



FIG. 26.—Schedule of work in the drafting department.

is responsible for routing, it will have a tendency to bring to bear more strongly the question of final cost and the cheapest ways and means for finishing the piece, all of which is to the advantage of the firm. *Routing* must not be confused with *dispatching*. Routing simply assigns the sequence of operations, and chooses the machines best fitted to perform them, while dispatching takes actual charge of the timing of their movements through the shop. This latter is hardly ever placed under the control of the designing department as it would be an encumbrance upon them and they are not in position to handle it.

When work is routed from the drafting room, the principles and forms used for this purpose are the same as when it is done in the shop. The work is usually done by a process engineer who studies the proper sequence of operations. Under him is the tool designer. The instruction cards for each operation are made out by clerks who work under the direction of the process engineer.

**93. Compensation methods in drafting rooms.** Little has been done successfully in the matter of compensation of draftsmen other than by day-work. One or two instances are recorded in which a bonus has been paid at the end of each year, in some cases depending on the length of service and in others on the absence of mistakes which caused expenditure to correct. The first method necessitates setting aside a sum or appropriation for the year's drafting

expense and then giving a bonus of one-half the amount saved. This is divided up in proportion to factors obtained by multiplying the number of months of service by the day-rate. The tendency of this system is to keep down the number of draftsmen. The system which is based on expense of errors sets aside an annual arbitrary sum which is to be used as a bonus and keeps an individual record of the errors of each draftsman. One-third of the cost of correcting his errors is deducted from his share of the bonus. The second system would seem to be the most logical one, but in any case it is difficult to standardize the draftsman's day's work, which would be essential to the successful use of special compensation methods. And it does not pay to have them work unduly for speed at the expense of accuracy, since the small amount saved in the drawing room might result in great loss in the shop.

## SECTION III

# EQUIPMENT CONTROL

## SELECTION OF EQUIPMENT

**94. Equipment.** Equipment comprises everything within the plant aside from the direct and indirect materials, and the labor which is applied directly and indirectly on the product. It enters into the cost of the product indirectly, through fixed charges which are set to represent its depreciation and sometimes also the interest on the investment as well.

**95. Functions of management with respect to equipment.** The functions of management with respect to equipment of any kind may be classified as follows:

(*a*) Selection and purchase. (*b*) Installation. (*c*) Use. (*d*) Repair. (*e*) Discarding.

Good management has definite ways of performing these functions to do them most efficiently, and it also employs definite methods of recording the performance of these functions.

**96. Effect of the various factors on total efficiency.** It is commonly thought that equipment efficiency is based on operation or use only, which is quite wrong. For example, a machine not at all suited to the work might be purchased and operated. It might have a high operating efficiency based upon its total possible capacity as compared to what it actually turned out, but its total efficiency would be low on account of its not being suited for the purpose. This is a case where improper selection reduces total efficiency. Again, an efficient tool may be inefficiently operated, with detriment to the total efficiency, or it may be inefficiently repaired and lose time through shut-downs, which has the same effect. Another point which affects total efficiency of equipment is the use of a machine after it should be discarded, although its relative operating efficiency may still be high. It will be seen that every one of the five functions of management with respect to equipment affect its total efficiency and must be studied with respect to making the best use of each.

**97. Definition of total equipment-efficiency.** It is hard to arrive at a definite means of figuring the actual total efficiency of any piece of equipment, for the reason that we rarely ever know positively what is "best performance" of any of the above functions, which would be necessary to arrive at a definite percentage, since efficiency may be said to consist broadly of:

$$\frac{\textit{Actual Results}}{\textit{Best Results}}$$

The standard for "best results" is a constantly changing one, depending on progress and invention; for example, a machine which two years ago was the best possible selection for a given job might be far from the best at the present time. When equipment is selected, however, the future cannot be foreseen, therefore the com-

parison must be made at the time of selection, leaving the discarding function to take care of this feature.

**98. Maximum total efficiency of equipment is reached when the following requirements are satisfied:**

(*a*) The machine selected is the best one, at the time of selection, for the given job.

(*b*) It is purchased on the most favorable terms and at quickest delivery. (Quick delivery because we cannot make use of the best any too soon.)

(*c*) It is installed in the most suitable location, in the best manner, and in the least time.

(*d*) Its continuous operation is as near to the maximum possible as can be had.
Repairs are made with the least interruption to production, and in the most permanent or lasting manner.

(*e*) It is discarded as soon as the comparison between first cost and increased production of an improved machine shows a good investment.

Since these five conditions are never perfectly fulfilled, the total efficiency of equipment never reaches 100 per cent. It is probably on the average nearer to 20 or 30 per cent. Strict adherence to these five principles will undoubtedly have the effect of raising it.

**99. The selection of equipment.** A machine that is to operate for 5 or 10 years is often selected in a few hours. An error in selection is made once, but its effects are repeated every day that the machine is used. Proper selection is therefore the most important function of management with respect to equipment. This is especially true of "direct" equipment, which performs labor directly upon the product.

The first requisite of proper selection is a knowledge of the existing types of machines which are capable of doing the work. It is seldom that any one shop contains all of these types, or that any one shop executive is familiar with all of them through personal observation or handling. This is one of the functions of technical literature, both as regards subject matter and advertising pages. After a knowledge of the existing types and makes of machine is obtained, more specific information may be had by securing the catalogs pertaining to them. The general specifications contained in these catalogs will help to reduce the number of possible selections by a process of elimination.

**100. Proper selection is made easier if the intended use is thoroughly outlined.** A great many machines are purchased without a clear idea of this, especially in shops where there is a large variety of work. Where the machine is to be restricted to a small variety or one operation the problem is much easier. Where there is considerable variety, certain leading pieces and operations can be selected and analyzed on the following lines:

(*a*) Quantities to be handled. (Determining the choice of automatic or semi-automatic.)

(*b*) Prevailing operations. (Determining the general type, chucking or center.)

(*c*) Nature of cuts. (Determining weight of machine and power.)
(*d*) Degree of finish. (Determining general accuracy and sometimes type.)

Some well-managed plants go a step farther in this respect, analyzing the speeds and feeds which will be best suited to the work involved and embodying them as part of the specifications, or selecting makes which approach the selected factors most nearly, other things being equal. (See Standardization of machine speeds, feeds, and tools, 177.)

The nearer the machine approaches a "one-operation" machine, the more nearly and definitely can its requirements be defined, and the more will it approach a special machine built to order.

**101.** Having a definite idea of what is wanted, the next step is to tabulate the various possible selections with regard to important features, some of which are as follows:

(*a*) Make. (General reputation sometimes is an important factor where more intimate knowledge is not to be had.)
(*b*) Weight. (Not always indicating value, but the lightest machine of a number of similar type must show proof of durability.)
(*c*) Operating conveniences.
(*d*) Automaticity. (Degree of skill required to operate.)
(*e*) Power. (A comparison of belt widths, gear ratios.)
(*f*) Speeds and feeds. (Uniform range.)
(*g*) Ease of repair.
(*h*) Safety.
(*i*) Production guarantees on typical work.
(*j*) Price.
(*k*) Delivery.

The steps indicated above will result in further elimination of makes until there are only a few possible selections remaining. If the individual who is responsible for the selection is not familiar with these remaining machines in their improved forms, it will pay him to make a point of seeing each one in operation before deciding. A trip for this purpose is a good investment, since the absence of information on one small point may result in a poor choice and repeated losses. If it is possible, a machine operator should be questioned regarding the good and bad points, and information secured as to the amount of repairs found necessary.

**102. Analysis of Equipment:**

**Direct-Equipment.**

- **Primary.** (Performing labor directly on the product.)
  - Machine tools.
  - Punches, presses, forming machines.
  - Steam hammers, forging machines.
  - All other productive machinery.
- **Secondary.** (Assisting the primary in its action.)
  - Jigs, fixtures.
  - Small tools and appliances.
- **Supplementary.** (Facilitating hand labor.)
  - Benches.
  - Vises.
  - Hand tools.

**Indirect Equipment.**

**Power Producing Equipment.**
Boilers, engines, condensers, heaters, economizers, compressors, feed pumps, ash and coal handling machinery.
**Power Transmission Equipment.**
Motors and wiring, rope drive, transformers, line-shafts, pulleys and hangers, countershafts and jack-shafts, main, overhead and machine belts, compressed air lines.
**Handling and Transporting Equipment.**
Industrial tracks, cars and locomotives, travelling and stationary cranes, hoists and chain blocks, wagons, shop trucks, portable racks, mechanical conveyors, elevators, chutes, racks, bins and shelves.

**Safety Equipment.**

**Safety Appliances.**
Machine and belt guards, first-aid apparatus, warnings, fire pumps, sprinkler system, high-pressure mains and hydrants, fire escapes, fire alarms, etc.
**Sanitary Equipment.**
Closets, fountains, wash-room fittings, lockers, low-pressure tank lines and pumps, drains and sewers.
**Registering Equipment.**
Time clocks and recorders, watchmen's clocks and stations, etc.
**Miscellaneous Equipment.**
Telephone lines, automatic calls, shop-office furniture, etc.

**103. Purpose of equipment.** All items of equipment should be installed for the purpose of helping or doing away with hand or mental labor, or making it safer or more comfortable. An article which does not do one of these things is hardly worth putting into a plant.

**104. Indexing equipment information.** The shop executive who is interested in selecting equipment will find it of advantage to maintain sources of information for quick reference. These include catalogs, circulars, clippings from advertising pages, trade directories and so on. New improvements in machines are usually described in full in the technical press and these articles are of use and should be filed.

Catalogs, owing to their various sizes, are usually numbered and filed in book cases or on shelves arranged in order of page size, a cross-index being kept according to subject and referring to catalog number. Clippings may be filed in envelopes which are numbered and indexed in the same way.

A useful form of information is that regarding the sizes of machines built by various manufacturers. For example, it is desired to buy a certain size machine and the question arises as to which makers build machines of that size. This necessitates searching through catalogs which are not always made with an idea of convenience in finding this information. A loose-leaf note book or card index arranged by machine type and size, referring to the makers of that particular machine saves a great deal of time.

**105. Determining if a machine is a good investment.** Since manufacturers of machinery are getting into the habit of making production guarantees on machines which they offer for sale, it becomes a matter of simple arithmetic to figure the probable return on the money which is to be invested, or looking at it from another way, to figure how much can be spent for a given machine to keep within the expected return.

**106. Permissible Equipment-investment Table.**

| Depreciation charge, per cent. | 10 | | | 20 | | | 20 | | | 40 | | | 50 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Per cent. return demanded | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 |
| Annual savings to be effected | $\frac{S}{0.20}$ | $\frac{S}{0.30}$ | $\frac{S}{0.40}$ | $\frac{S}{0.30}$ | $\frac{S}{0.40}$ | $\frac{S}{0.50}$ | $\frac{S}{0.40}$ | $\frac{S}{0.50}$ | $\frac{S}{0.60}$ | $\frac{S}{0.50}$ | $\frac{S}{0.60}$ | $\frac{S}{0.70}$ | $\frac{S}{0.60}$ | $\frac{S}{0.70}$ | $\frac{S}{0.80}$ |
| $ 10 | 50 | 33.33 | 25.00 | 33.33 | 25.00 | 20 | 25.00 | 20 | 16.66 | 20 | 16.66 | 14.28 | 16.66 | 14.28 | 12.50 |
| 25 | 125 | 83.33 | 62.50 | 83.33 | 62.50 | 50 | 62.50 | 50 | 41.66 | 50 | 41.66 | 35.70 | 41.66 | 35.70 | 31.20 |
| 50 | 250 | 166.66 | 125.00 | 166.66 | 125.00 | 100 | 125.00 | 100 | 83.33 | 100 | 83.33 | 71.40 | 83.33 | 71.40 | 62.50 |
| 75 | 375 | 250.00 | 187.50 | 250.00 | 187.50 | 150 | 187.50 | 150 | 125.00 | 150 | 125.00 | 107.10 | 125.00 | 107.10 | 93.70 |
| 100 | 500 | 333.33 | 250.00 | 333.33 | 250.00 | 200 | 250.00 | 200 | 166.66 | 200 | 166.66 | 142.85 | 166.66 | 142.85 | 125.00 |
| 150 | 750 | 500.00 | 375.00 | 500.00 | 375.00 | 300 | 375.00 | 300 | 250.00 | 300 | 250.00 | 214.28 | 250.00 | 214.28 | •187.50 |
| 200 | 1,000 | 666.66 | 500.00 | 666.66 | 500.00 | 400 | 500.00 | 400 | 333.33 | 400 | 333.33 | 285.71 | 333.33 | 285.71 | 250.00 |
| 250 | 1,250 | 833.33 | 625.00 | 833.33 | 625.00 | 500 | 625.00 | 500 | 416.66 | 500 | 416.66 | 357.14 | 416.66 | 357.14 | 312.50 |
| 300 | 1,500 | 1,000.00 | 750.00 | 1,000.00 | 750.00 | 600 | 750.00 | 600 | 500.00 | 600 | 500.00 | 428.57 | 500.00 | 428.57 | 375.00 |
| 350 | 1,750 | 1,166.66 | 875.00 | 1,166.66 | 875.00 | 700 | 875.00 | 700 | 583.33 | 700 | 583.33 | 500.00 | 583.33 | 500.00 | 437.50 |
| 400 | 2,000 | 1,333.33 | 1,000.00 | 1,333.33 | 1,000.00 | 800 | 1,000.00 | 800 | 666.66 | 800 | 666.66 | 571.42 | 666.66 | 571.42 | 500.00 |
| 500 | 2,500 | 1,666.66 | 1,250.00 | 1,666.66 | 1,250.00 | 1,000 | 1,250.00 | 1,000 | 833.33 | 1,000 | 833.33 | 714.28 | 833.33 | 714.28 | 625.00 |
| 600 | 3,000 | 2,000.00 | 1,500.00 | 2,000.00 | 1,500.00 | 1,200 | 1,500.00 | 1,200 | 1,000.00 | 1,200 | 1,000.00 | 857.14 | 1,000.00 | 857.14 | 750.00 |
| 700 | 3,500 | 2,333.33 | 1,750.00 | 2,333.33 | 1,750.00 | 1,400 | 1,750.00 | 1,400 | 1,166.66 | 1,400 | 1,166.66 | 1,000.00 | 1,166.66 | 1,000.00 | 875.00 |
| 800 | 4,000 | 2,666.66 | 2,000.00 | 2,666.66 | 2,000.00 | 1,600 | 2,000.00 | 1,600 | 1,333.33 | 1,600 | 1,333.33 | 1,142.85 | 1,333.33 | 1,142.85 | 1,000.00 |
| 900 | 4,500 | 3,000.00 | 2,250.00 | 3,000.00 | 2,250.00 | 1,800 | 2,250.00 | 1,800 | 1,500.00 | 1,800 | 1,500.00 | 1,285.71 | 1,500.00 | 1,285.71 | 1,125.00 |
| 1,000 | 5,000 | 3,333.33 | 2,500.00 | 3,333.33 | 2,500.00 | 2,000 | 2,500.00 | 2,000 | 1,666.66 | 2,000 | 1,666.66 | 1,428.57 | 1,666.66 | 1,428.57 | 1,250.00 |
| 1,100 | 5,500 | 3,666.66 | 2,750.00 | 3,666.66 | 2,750.00 | 2,200 | 2,750.00 | 2,200 | 1,833.33 | 2,200 | 1,833.33 | 1,571.42 | 1,833.33 | 1,571.42 | 1,375.00 |
| 1,200 | 6,000 | 4,000.00 | 3,000.00 | 4,000.00 | 3,000.00 | 2,400 | 3,000.00 | 2,400 | 2,000.00 | 2,400 | 2,000.00 | 1,714.28 | 2,000.00 | 1,714.28 | 1,500.00 |
| 1,300 | 6,500 | 4,333.33 | 3,250.00 | 4,333.33 | 3,250.00 | 2,600 | 3,250.00 | 2,600 | 2,166.66 | 2,600 | 2,166.66 | 1,857.14 | 2,166.66 | 1,857.14 | 1,625.00 |
| 1,400 | 7,000 | 4,666.66 | 3,500.00 | 4,666.66 | 3,500.00 | 2,800 | 3,500.00 | 2,800 | 2,333.33 | 2,800 | 2,333.33 | 2,000.00 | 2,333.33 | 2,000.00 | 1,750.00 |
| 1,500 | 7,500 | 5,000.00 | 3,750.00 | 5,000.00 | 3,750.00 | 3,000 | 3,750.00 | 3,000 | 2,500.00 | 3,000 | 2,500.00 | 2,142.85 | 2,500.00 | 2,142.85 | 1,875.00 |
| 1,600 | 8,000 | 5,333.33 | 4,000.00 | 5,333.33 | 4,000.00 | 3,200 | 4,000.00 | 3,200 | 2,666.66 | 3,200 | 2,666.66 | 2,285.71 | 2,666.66 | 2,285.71 | 2,000.00 |
| 1,700 | 8,500 | 5,666.66 | 4,250.00 | 5,666.66 | 4,250.00 | 3,400 | 4,250.00 | 3,400 | 2,833.33 | 3,400 | 2,833.33 | 2,428.57 | 2,833.33 | 2,428.57 | 2,125.00 |

**Permissible Equipment-investment Table.** *Continued.*

| Depreciation charge, per cent | 10 | | | 20 | | | 30 | | | 40 | | | 50 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Per cent. return demanded | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 |
| Annual saving to be effected | $\frac{S}{0.20}$ | $\frac{S}{0.30}$ | $\frac{S}{0.40}$ | $\frac{S}{0.30}$ | $\frac{S}{0.40}$ | $\frac{S}{0.50}$ | $\frac{S}{0.40}$ | $\frac{S}{0.50}$ | $\frac{S}{0.60}$ | $\frac{S}{0.50}$ | $\frac{S}{0.60}$ | $\frac{S}{0.70}$ | $\frac{S}{0.60}$ | $\frac{S}{0.70}$ | $\frac{S}{0.80}$ |
| $1,800 | 9,000 | 6,000.00 | 4,500.00 | 6,000.00 | 4,500.00 | 3,600 | 4,500.00 | 3,600 | 3,000.00 | 3,600 | 3,000.00 | 2,571.42 | 3,000.00 | 2,571.42 | 2,250.00 |
| 1,900 | 9,500 | 6,333.33 | 4,750.00 | 6,333.33 | 4,750.00 | 3,800 | 4,750.00 | 3,800 | 3,166.66 | 3,800 | 3,166.66 | 2,714.28 | 3,166.66 | 2,714.28 | 2,375.00 |
| 2,000 | 10,000 | 6,666.66 | 5,000.00 | 6,666.66 | 5,000.00 | 4,000 | 5,000.00 | 4,000 | 3,333.33 | 4,000 | 3,333.33 | 2,857 14 | 3,333.33 | 2,857.14 | 2,500.00 |
| 2,500 | 12,500 | 8,333.33 | 6,250.00 | 8,333.33 | 6,250.00 | 5,000 | 6,250.00 | 5,000 | 4,166.66 | 5,000 | 4,166.66 | 3,571.42 | 4,166.66 | 3,571.42 | 3,125.00 |
| 3,000 | 15,000 | 10,000.00 | 7,500.00 | 10,000.00 | 7,500.00 | 6,000 | 7,500.00 | 6,000 | 5,000.00 | 6,000 | 5,000.00 | 4,285.71 | 5,000.00 | 4,285.71 | 3,750.00 |
| 3,500 | 17,500 | 11,666.66 | 8,750.00 | 11,666.66 | 8,750.00 | 7,000 | 8,750.00 | 7,000 | 5,833.33 | 7,000 | 5,833.33 | 5,000.00 | 5,833.33 | 5,000.00 | 4,375.00 |
| 4,000 | 20,000 | 13,333.33 | 10,000.00 | 13,333.33 | 10,000.00 | 8,000 | 10,000.00 | 8,000 | 6,666.66 | 8,000 | 6,666.66 | 5,714.28 | 6,666.66 | 5,714.28 | 5,000.00 |
| 4,500 | 22,500 | 15,000.00 | 11,250.00 | 15,000.00 | 11,250.00 | 9,000 | 11,250.00 | 9,000 | 7,500.00 | 9,000 | 7,500.00 | 6,428.57 | 7,500.00 | 6,428.57 | 5,625.00 |
| 5,000 | 25,000 | 16,666.66 | 12,500.00 | 16,666.66 | 12,500.00 | 10,000 | 12,500.00 | 10,000 | 8,333.33 | 10,000 | 8,333.33 | 7 142.85 | 8,333.33 | 7,142.85 | 6,250.00 |
| 5,500 | 27,500 | 18,333.33 | 13,750.00 | 18,333.33 | 13,750.00 | 11,000 | 13,750.00 | 11,000 | 9,166.66 | 11,000 | 9,166.66 | 7,857.14 | 9,166.66 | 7,857.14 | 6,875.00 |
| 6,000 | 30,000 | 20,000.00 | 15,000.00 | 20,000.00 | 15,000.00 | 12,000 | 15,000.00 | 12,000 | 10,000.00 | 12,000 | 10,000.00 | 8,571.42 | 10,000.00 | 8,571.42 | 7,500.00 |
| 6,500 | 32,500 | 21,666.66 | 16,250.00 | 21,666.66 | 16,250.00 | 13,000 | 16,250.00 | 13,000 | 10,833.33 | 13,000 | 10,833.33 | 9,285.71 | 10,833.33 | 9,285.71 | 8,125.00 |
| 7,000 | 35,000 | 23,333.33 | 17,500.00 | 23,333.33 | 17,500.00 | 14,000 | 17,500.00 | 14,000 | 11,666.66 | 14,000 | 11,666.66 | 10,000.00 | 11,666.66 | 10,000.00 | 8,750.00 |
| 7,500 | 37,500 | 25,000.00 | 18,750.00 | 25,000.00 | 18,750.00 | 15,000 | 18,750.00 | 15,000 | 12,500.00 | 15,000 | 12,500.00 | 10,714.28 | 12,500.00 | 10,714.28 | 9,375.00 |
| 8,000 | 40,000 | 26,666.66 | 20,000.00 | 26,666.66 | 20,000.00 | 16,000 | 20,000.00 | 16,000 | 13,333.33 | 16,000 | 13,333.33 | 11,428.57 | 13,333.33 | 11,428.57 | 10,000.00 |
| 8,500 | 42,500 | 28,333.33 | 21,250.00 | 28,333.33 | 21,250.00 | 17,000 | 21,250.00 | 17,000 | 14,166.66 | 17,000 | 14,166.66 | 12,142.85 | 14,166.66 | 12,142.85 | 10,625.00 |
| 9,000 | 45,000 | 30,000.00 | 22,500.00 | 30,000.00 | 22,500.00 | 18,000 | 22,500.00 | 18,000 | 15,000.00 | 18,000 | 15,000.00 | 12,857.14 | 15,000.00 | 12,857.14 | 11,250.00 |
| 9,500 | 47,500 | 31,666.66 | 23,750.00 | 31,666.66 | 23,750.00 | 19,000 | 23,750.00 | 19,000 | 15,833.33 | 19,000 | 15,833.33 | 13,571.42 | 15,833.33 | 13,571.42 | 11,875.00 |
| 10,000 | 50,000 | 33,333.33 | 25,000.00 | 33,333.33 | 25,000.00 | 20,000 | 25,000.00 | 20,000 | 16,666.66 | 20,000 | 16,666.66 | 14,285.71 | 16,666.66 | 14,285.71 | 12,500.00 |

The following example illustrates the calculations made to determine if a new machine will be a good investment. The present machine has a capacity of 10,000 pieces per year, at a total labor cost of $900. The proposed machine has a capacity of 15,000 pieces per year at a labor cost of $1000. We assume a depreciation rate of 15 per cent., and we insist upon a similar return on our investment, as a minimum. How much may we expend for the new machine?

The new machine will produce 5000 additional pieces per year. These cost on the old machine $\frac{\$900}{10,000}$ or 9 cents each. Therefore were the operators on the two machines to be paid at the same rate, the saving due to the increased output would be $0.09 \times 5000$ or $450 per year. However, we will have to pay the operator of the new machine $100 more which will reduce this to $350. Dividing this saving by the sum of the depreciation and the investment return rate, gives us

$$\frac{\$350}{0.15 + 0.15} = \$1166.66$$

which represents the maximum amount we can pay for the machine.

Notice that the cost of the old machine, and its depreciation rate, do not enter into the problem. It is simply a question as to whether the new machine can earn enough over *its* depreciation to pay a minimum required return.

The relative amount of power used by average machines is so much less than the cost of the man-power required that it does not pay to consider it except in cases of extremely heavy machines requiring hundreds of horse power, where it of course becomes an item.

Tables showing the amounts which may be invested for various investment return rates and various depreciation rates will be found in paragraph (106). The same method of calculating may be applied to machinery that is built in the factory such as jigs, fixtures and special tools.

**107. The selection of non-productive equipment.** More difficulty is encountered in making a selection, or deciding upon the necessity of non-productive equipment, on account of not being able to figure the probable investment return in an easy manner. A great portion of it is not used continuously, being supplementary to productive equipment, or used to assist the workers when occasion demands. The result is that the proportion of unnecessary equipment found in the average plant is higher in the non-productive class than in the productive. It is a hard matter to sell a man a tool for which he has no use, but every shop bears witness to the persuasiveness of the equipment salesman in the presence of non-productive equipment which is more ornamental than useful.

Deciding whether or not a certain piece of equipment of this kind is necessary, is helped by turning to our statement of the purpose of equipment. It must replace or facilitate hand labor, or make it more agreeable and safer, before it can be said to be a good investment.

As a typical illustration of the solution of a problem relat-

ing to non-productive equipment, take that of replacing a chain block by an electric hoist. The machine served is a boring machine operating on flywheels which weigh approximately 500 pounds each, each of which consumes an average of 2 hours on the machine. Will it pay to replace the slow hand-operated chain block by an electric hoist? The apparatus will not average over five lifts a day, 3 feet to a lift. During the year we will make 1500 lifts, probably, and the total movement will amount to 9000 feet. The average rate of lifting and lowering with the chain block we can assume is 2 feet per minute, and with the electric hoist, 20 feet per minute. The time of the machine and operator together is valued at $1 per hour. The saving will be due to the more rapid action of the electric hoist, not from any difference in time in making the hitches which will be the same in the case of either hoist. The electric hoist will cut the 75 hours we are now spending for raising and lowering, down to 7½ hours per annum. At $1 per hour, this annual saving will be $67.50. Its cost will be $250. The depreciation, at 15 per cent., will amount to $37.50. The net saving will be $30 per year, over and above depreciation, or a return of 12 per cent. It would be a doubtful investment in thiscase, especially as the energy savings would not be important. But the restriction of the electric hoist to a machine which can use it but such a short part of its available time is doing this piece of equipment an injustice. If it could be extended to serve three such machines, for example, there would be no question about its desirability.

There is another solution for the single machine, however. Our chain block is undoubtedly suspended from a simple jib arrangement of beam construction. The whole thing, block and all could be easily duplicated for $100. Why not, therefore, rig up a duplicate hand hoist over this same machine, so that all the hoisting and lowering could be done while the machine was in operation, thus saving the whole $75 instead of $67.50. The return in this case, with a 15 per cent. depreciation rate, would be 60 per cent. on our money. This illustrates the method of dealing with proposed non-productive equipment improvements; first see how much unnecessary labor you can eliminate with the proposed device, and then see if there isn't something else which will save it all!

In some cases it is impossible to figure or even approximate the return on new equipment. Take the case of the installation of a heating system. This comes under the classification of providing comfort for the employees. It has an effect on profits, however, as anyone with experience in a cold shop can testify. And in a case of this kind, it pays to make sure that the apparatus is quite adequate for its work, for a few hundred dollars saved on initial cost is soon eaten up when producers are forced to keep their hands in their pockets, and incidentally in the company's pocket at the same time.

**108. The selection of minor equipment, tool steels.** The selection of various small tools, such as reamers, drills, taps, and of tool steel, high-speed and otherwise, is a matter of great im-)rtance, since it contributes directly to the efficiency or in-ciency of the machine tools in which these articles are used.

Some plants adopt a policy of placing orders for this minor equipment in return for business favors or orders, considering it as a matter of small importance. This is poor management indeed. The best from point of service and cost is none too good for any factory whose profits depend upon the daily use of these commodities. While the principles applying to the purchase of direct equipment relate also to this class, the selection or standardization of minor equipment is usually made from tests and through the experience of use.

In this connection it is good policy to insist on a report of every new thing that is tried out, and to take pains to have it tried out in enough departments to secure an unbiased report. Any article showing marked superiority can then be tested more fully and adopted as a standard if found desirable.

The factory manager is confronted almost daily with the representative of some steel company, especially makers of high-speed steel, with the request that he try a sample piece and see how much better it is than anything that he has ever used. The indiscriminate trial of such samples is merely a waste of time, since if the one sample should secure better results on the class of work tried, it is not an indication that it will be a better all-round steel to use, the determination of the best all-round steel being something that requires extensive use, on all operations lasting over long periods, to determine. It is often a delicate matter to refuse to try out the proffered sample; at the same time the number of these that are offered make it quite a nuisance to say the least. This is avoided by standardizing a cutting steel which has proved to be best for a period of 1 year or 2 years, and then accepting samples for general comparison at the termination of this period. Thus if anything better has developed or been produced, it will be discovered and the necessity of frequently trying out samples is gracefully avoided.

**109.** In standardizing tools such as reamers, which have a definite cutting size that is lost after a period of use, it is well to install a temporary system of records giving information as to the number of holes reamed with each tool. The results obtained are sometimes surprising in the matter of tool cost per hole, especially on work which is held within strict limits. In one case the author found that the tool cost per hole for finishing reamers was greater than the labor cost (piecework) of the complete hole, including drilling and reaming.

When small equipment becomes standardized as the results of such tests, under no conditions should the purchases be made elsewhere without written orders from the management. Where there is a division of control between the purchasing and the factory management, considerable dodging of responsibility results from purchases which are made without the approval of the shop management.

**110. Building special machines versus buying.** A plant is fundamentally in business to produce a given product and to sell it at a given profit. Floor space is assumed to be valuable for this purpose as the average plant is either up to capacity during

normal times, or rather behind it in good times. Therefore it will not pay to occupy floor space to make something that can be bought for our cost plus our normal margin of profit, for we would be nothing ahead, and in addition would have spent considerable energy not included in the cost figures. The construction of anything outside of the regular line has a tendency to interrupt related thinking and distract the attention of those who are looking after the product, unless the organization is especially provided with proper divisions for this purpose.

In past years, many plants could be found making even standard small tools, such as taps, reamers, and dies. The installation of cost-finding methods into the tool department put a stop to this because it proved that better goods could be purchased for less money. And at the present date, the tendency is also toward having the special machinery, the more complicated jigs and special tools, made to order by those who make a business of doing it, for the double reason of saving time and effort and obtaining a better article. The one drawback seems to be the question of prompt delivery, although one who has had experience in getting special work through the average tool department knows that this does not constitute such a strong argument against purchasing them.

**111. The purchase of equipment.** See (178–186) relating to purchasing methods in general.

## INSTALLATION AND REPAIR

**112. The installation of equipment.** The factors entering into the installation of equipment after it is received are as follows:

(*a*) *Choice of location*. This has a large effect upon its future operating efficiency and must be made with care, consideration being given to the principles outlined in (142–150). The choice of location is something that should be made as soon as the machine is decided upon and ordered, so that there will be no delay for this purpose after he machine arrives. In case the location of the new machine necessitates the moving of other machines already in place, this should be also accomplished prior to the arrival of the new machine and with as little interruption to work as possible. Planning applied to machine moving effects as great economies as it does elsewhere, the actual moving taking but little time. Foundations may be placed without interrupting production, as may countershafts and other overhead works, and the actual moving done when the shop is closed.

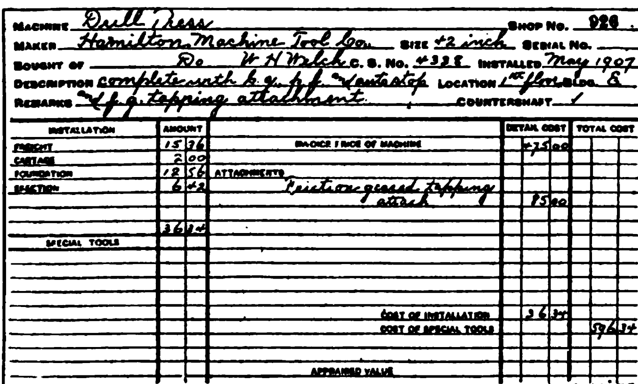
(*b*) *Foundations* must be proportionate to the machine and work involved. Numerous machines have their maximum capacity reduced by lack of substantial foundations or support, especially those located on upper floors which cannot be run at proper speed on account of the vibration that results. The foundations for new machines should be in place and ready for their arrival.

(*c*) *Drive*. The drive should be planned, size of pulleys determined and the pulleys secured, the main drive pulley mounted on the line shaft and the belting purchased prior to the arrival

of the machine. It is good practice to have machine countershafts shipped in advance of the machine so that still further preparation may be made and everything be in readiness for placing the machine on its foundation and putting on the machine belt.

(*d*) ***Inspection after installation.*** Inspection of the machine after installation should be a matter of routine. It should not only be for the purpose of checking up the machine itself for accuracy and completeness, but should check up the work of installation, see that belts are properly adjusted and that the driving power is ample, note that the highest speed may be used without vibration, and such points. This work is under the supervision of the master mechanic, who should instruct the operator at that time about proper care of the machine, oiling and the like, if the makers have not sent a demonstrator, in which case these instructions may be left to him.

**113. Installation records.** A record of the cost of installation should be made for each tool, preferably on a form which also records the cost of the complete machine and other details regarding it. Such a form is illustrated in Fig. 27, being the one used by the Cleveland Automatic Machine Co. for that purpose.



MACHINE Drill Press SHOP NO. 926
MAKER Hamilton Machine Tool Co. SIZE 42 inch SERIAL NO.
BOUGHT OF Do W H Welch C. S. NO. 4338 INSTALLED May 1907
DESCRIPTION complete with b.g. p.f. & centerstop LOCATION 1st floor BLDG. E
REMARKS & f.g. tapping attachment COUNTERSHAFT 1

| INSTALLATION | AMOUNT | | DETAIL COST | TOTAL COST |
|---|---|---|---|---|
| FREIGHT | 15 36 | INVOICE PRICE OF MACHINE | 475 00 | |
| CARTAGE | 2 00 | | | |
| FOUNDATION | 12 56 | ATTACHMENTS | | |
| ERECTION | 6 42 | Friction geared tapping attach | | |
| | | | 85 00 | |
| | | | | |
| | 36 34 | | | |
| SPECIAL TOOLS | | | | |
| | | COST OF INSTALLATION | 36 34 | |
| | | COST OF SPECIAL TOOLS | | 596 34 |
| | | APPRAISED VALUE | | |

American Machinist, N.Y.

FIG. 27.—Form of card for plant account.

**114. The use of productive equipment.** This is inseparably connected with production, both as to principles involved and records, and will be found described under Production Methods.

**115. The repair of equipment.** The repair of equipment, and especially of the productive machinery, is an important matter. A machine of this type has a certain maximum earning capacity which is never attained, first, because it is never operated at perfect efficiency, and second, because it does not operate full time. While we cannot insure against the occasional absence of the operator in all cases, we can make certain that repairs are executed promptly and properly and that earning capacity will be handi-

capped as little as possible through shut-downs arising from this factor.

If a machine is idle 3 days out of a possible 300, it loses 1 per cent. of its earning power. If it is idle a week, it loses 2 per cent. Three days a year per machine for repairs, and 3 days for absence of operator is probably a better score than is obtained in the average shop, but it means that 2 cents are taken out of the possible dollar before it gets started. Why not make the repairs on the days when we are forced to shut the machine down due to the absence of its operator, thus saving 1 of the 2 cents?

Machine member repairs, exclusive of breakdowns which occur suddenly from improper handling, can be anticipated. Comparatively few repairs originate from a sudden accident, the majority of them being the culmination of gradual wear, or continued misadjustment. All of these are preventable. If machinery is kept in what may be called a good condition of repair, the majority of such shut-downs will be eliminated. And whenever possible, machine overhauling should be done on those days when the machine is shut down through lack of an operator. Then the repair costs nothing, aside from the actual labor and material put into it, whereas in other cases it charges double rates in addition to stealing some of the profits.

The attainment of a good condition of machine repair necessitates that the organization be provided with a proper unit with the authority and responsibility of looking after it. The department foreman as a rule has his hands too full to do more than notify the tool room that a tool is out of commission, and cannot apply the anticipation which will prevent the shut-down.

**116. Chronic breakdowns.** In some cases, machines are found with parts too weak for the work they are called upon to do. They get what may be called the "chronic breakdown" habit. When the same break occurs three times in succession it is useless and extravagant to replace the parts without change. It may cost 10 times as much to design and provide stronger parts, and it will be a whole lot more trouble than to slip in such standard parts as we have on hand, but it will be a step toward the proper control of equipment, which is to regard each machine as an employee whose salary we must pay whether he works or not, and to take steps to get our money's worth out of him. A tickler system as described in (118) may be made to serve for calling attention to such cases.

**117. Facilitating the filling of repair orders by a sketch of the part.** Repair orders for parts of machines that are not marked with a standard number, or for old machines, or in all cases where confusion in filling the order may result, are helped by sending a sketch of the part showing the principal features and dimensions. The time taken to do this is well spent in avoiding delays or unnecessary correspondence afterward. A carbon copy of the pencil sketch which is used in such cases should be preserved until the order is correctly filled.

**118. A tickler system applied to machine repair.** A useful form is shown in Fig. 28. This is used to remind those responsible for the repair condition of equipment of the date when inspection should

be made to determine its condition. After each such inspection, the necessary work is done, orders being made out for what is required, and the card held in an active rack until the repair is completed. It is then placed in the tickler case under a future date when the next inspection is to be made. The repair boss, or master mechanic, by going through his tickler daily can thus lay out the day's work easily, as far as inspection routine is concerned. The nature of the repair made is indicated on the card. This illustration also shows a case in which the same break occurred three

Machine No. 405 Universal Mill. Mach. #4

Department #14 Type Cont. Speed Drive

Installed Sept 1st 1913.

Bought From Machinery Supply Co.

Make Blank & Co

Inspect Monthly.

| Inspect. | Finding | Repaired |
|---|---|---|
| Oct. 1, 13 | Operator does not oil properly. No harm done yet | |
| Nov 1, 13 | Longitudinal Trip device worn. (Too Soft) | Nov. 3, 13 |
| Dec. 1, 13 | O.K. | |
| Jan 2, 14 | Trip device worn again (Reharden) | Jan. 3, 14 |
| (Jan 15) | Break-down due To broken longitudinal feed nut. (Defective Material) | Jan 22 |
| Feb. 1 | More trouble with Trip. Replace with hardened tool-steel finger. | Feb 4 |
| March 1 | O.K. | |
| | | |

FIG. 28.—A repair ticket used in machine inspection.

times, after which the part was replaced with one made of stronger material to avoid repetition of this trouble. The same system may be extended to keep track of detailed repair costs on each piece of equipment, however in this case it is desirable to use a different system of filing, as it would not be easy to locate a given machine in a tickler file. The repair file is most conveniently arranged by department and machine number. It serves a useful purpose in comparing two different makes of machines for ability to withstand hard service, although this comparison must be made with judgment aside from the facts, since one operator is often considerably harder on a machine than another.

**119. The inspection of equipment.** The maintenance of the efficiency of equipment, both direct and indirect, is of such importance that definite responsibility must be assigned to fully cover all classes of it. This may be done under one head, or the responsi-

starting and shutting down, unusual shut-downs and their reasons, overtime work on repairs.

Supplementing this for the purpose of checking efficiency of operation:

(*b*) Recording gage record of steam pressure. (See Fig. 31.)

(*c*) Recording gage record of air pressure at compressors.

(*d*) Recording wattmeter record of power generated. Sometimes also recorded as distributed to departments.

(*e*) Weekly inspection reports regarding the condition of equipment, leakage of steam, air, and water lines.

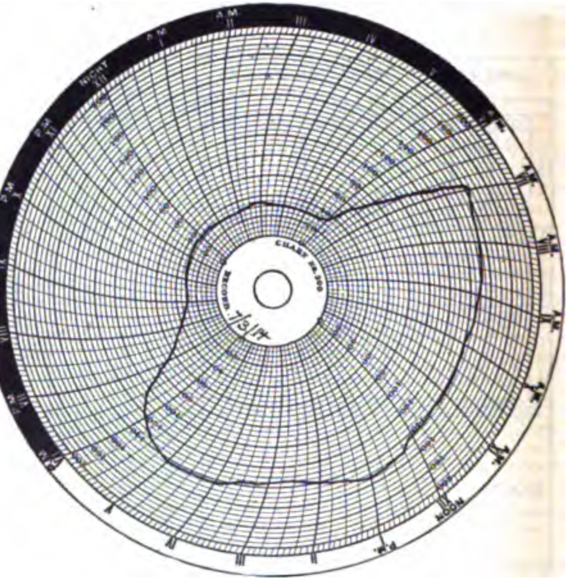



FIG. 31.—Recording gage record.

**122. Power transmission equipment reports.**

(*a*) Record of belts.

(*b*) Record of oil and grease consumption on overhead works.

(*c*) Weekly inspection reports concerning the condition of motors.

**123. Handling and transportation records.**

(*a*) Elevator inspection report; weekly.

(*b*) Record of the movements of shop trucks and of idle trucks.

**124. Safety appliances.**

Inspection reports as to fire apparatus; weekly, in connection with general report concerning shop cleanliness, condition of water barrels, fire hose.

**125. Sanitary equipment.**

(*a*) Weekly report as to general condition of cleanliness.

(*b*) Recording pressure gage record of service pressure maintained.

**126. Systems of caring for belts.** A large part of the work of getting the most out of a machine consists in providing it with sufficient power. On belt-driven machines, the belt is often, and in fact almost always, the limiting feature. If this is not in proper con-

dition, especially regarding tension, slip will result, power will be lacking to obtain maximum results and in addition the belts will wear out quickly. A belt of any size and length is an expensive item, and is worth caring for systematically. In many plants, the proper tension for each belt is determined, and secured by frequent adjustment upon a belt tension bench. This is a device which permits the tension to be measured before the belt is put in place, and determines the proper length to secure this tension. The center distance and size of pulleys is known. Adjusting the machine for these conditions, the belt is stretched, an idler pulley on a weighted lever arm bearing against it and furnishing the necessary tension. The exact length of belt which will give this tension when in place can thus be determined.

**127. Individual belt records are of value in keeping track of their maintenance cost,** and indirectly in calling attention to overloaded ones as indicated by the frequency of repairs. Records of this kind are usually in card form as shown in Fig. 32.

**128. A systematic inspection of belts** will prevent much loss of productive time. As a rule, all belts should be overhauled every 6 months, and those which are subject to heavy loads much more frequently, say once a month. Belts which run on step pulleys and are frequently shifted tend to stretch faster than others and must be looked after at least once a week. There should also be a regular routine in the matter of oiling and dressing belts, which quite properly may be done in connection with the shop oiling routine.

**129. Making new belts out of old ones.** Rather remarkable results are obtained by those who are in the business of renovating and building up old belts. The author has purposely sent belts which apparently were far beyond any possible further use, and has been surprised to see the serviceable material which was returned. Wide belts are reduced to narrower ones, by cutting out the bad spots. Double belts are split and made into single belts. The cleaning and building up is done in such a way that the appearance of the belt is like new, and the wear obtained from it is a good percentage of that obtainable from a new belt. In proportion to the cost of this service, which is slight, the extra length of life probably costs much less per time unit than in the case of a new belt. It is certainly economy to save every piece of belt, however worthless it may seem, and when enough has accumulated, send it to be renovated. This applies to leather belts only, canvas and rubber not presenting the possibility of renewal. The percentage of belt reclaimed varies with the condition of the old belts sent for renewing, but probably averages 60 per cent. in weight.

**130. Discarding equipment.** In discarding equipment, the same considerations enter into the question that were discussed under the purchase of new equipment. But there is another one of which we are reminded by the many old machines which have been transformed by minor changes into specialized ones, and are doing noble duty far beyond their normal expectation of life. In cases of this kind, where the old machine is practically worthless, those parts of it which may be used can be regarded as costing nothing.

DEPARTMENT........ BELT SYMBOL

## BELTING

LOCATION........................................ LENGTH OVER PULLEYS ........................ MAX. VELOCITY ..........

PURPOSE........................................ WIDTH........................................ MIN. VELOCITY ..........

KIND............................................ THICKNESS.................................... MAX. TENSION.......... } ON EACH SPRING BALANCE

MAKER'S NAME.................................. CROSS SECTION IN SQ. IN...................... MIN. TENSION..........

DATE PUT IN USE............................... HOW FASTENED.................................

DATE TAKEN OUT................................ BELT GREASE TO BE USED...................... COST OF BELT....................

LIFE OF BELT.................................. BELT DRESSING TO BE USED.................... COST OF MAINTENANCE............

TOTAL COST....................

| DATE RE-TIGHTENED | TENSION IN LBS. INDICATED BY EACH SPRING BALANCE | | AMOUNT TAKEN OUT | DATE TENSION AGAIN SHOULD BE TAKEN | DATE CLEANED AND GREASED | DATE TO BE CLEANED AND GREASED AGAIN | DATE DRESSING PUT ON DURING SERVICE | GENERAL REMARKS ABOUT WORK DONE ON BELT, CONDITION OF BELT ETC. | WORKMAN'S NAME | MAN'S TIME REQUIRED TO DO WORK | COST OF WORK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | BEFORE TIGHTENING | AFTER TIGHTENING | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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FIG. 32.—Belt record.

Many ingenious time savers have been constructed to perform a single operation by using the old beds and driving mechanisms and adding special attachments and fixtures. Often the multi-step cone is replaced by a single wide face pulley to give adequate power, and the feed mechanisms strengthened by replacing belts or cast-iron gears with wider faced gears of steel. Only one speed and feed are usually required on a machine of this type, and in addition to simplicity, this construction insures that the machine will be operated at the proper speed and feed.

**131. Machine and line shaft oiling.** The large amount of damage which may result from lack of proper attention to a single bearing in the matter of lubrication makes it necessary, especially in the machine shop, to place the responsibility for oiling the machines as well as the overhead shafts and idle pulleys on some particular individuals. It is bad practice to leave machine oiling to the operators, especially where a machine is used in common by a number of mechanics, as for example, shears, punches, brakes, used in metal working, and drilling machines used by various assemblers. It is human nature for one man to leave the oiling to another, or to assume that the man who ran the machine before him tended to it. An oiler should make rounds twice a day, and thoroughly oil such machines. Since oil holes are usually not prominent, and are likely to be overlooked, especially by a new oiler, it is a good scheme to make them more noticeable by painting red or yellow circles around them.

The policy of some concerns is to use grease cups wherever grease lubrication will serve, on account of the fact that it does not require such frequent attention as oil. This is a point well worth considering, not only from a question of lubrication value, but of time required to tend to it.

Overhead bearings connected with line and jack-shafts should be self oiling, to reduce the amount of attention required. However, they must not be overlooked altogether, as a seized bearing is likely to cost as much in loss of production through a whole department as the wages of the oiler for a month or two. The oiler should have a regular schedule of duties, some daily, some weekly, and some monthly, the locations and routes which he is to travel being specified for each day, so that self-oiling bearings will be tended to at sufficiently close intervals.

To compare the lubricating values of different grades of oil, the friction load of the various line-shafts should be determined. Where electric drive is used this is an easy matter, requiring simply voltmeter and ammeter readings for direct current, and wattmeter readings for alternating. When a new grade of oil is tested, after it has been in use long enough to become thoroughly distributed, an inspection of the amount of friction load as compared with that found when using the regular oil will be a fair test of the lubricating value as a power reducer. In addition, to compare length of service, it is a good plan to have records of the oil consumption per bearing per unit of time such as the week or month.

For central oil systems, see (249).

For methods of issuing oil, see (246).

## MACHINE NUMBERING

**132. Machine-tool numbering.** Numbers or symbols are applied to machine tools for the same reason that they are applied to product parts, namely, for brevity and ease of indexing. Some means must be had of indentifying each tool with shop records; its name, size and other characteristics must also be quickly available from the number or symbol. An important consideration is that of recovery for loss by fire, and this must be kept in mind when a numbering system is devised, so that there will be no difficulty in identifying the loss.

Among the *various forms and records* that entail machine-tool numbers are the following: Appraisal, Time cards, Route cards, Dispatching forms, Move tickets, Inspection cards, Repair tickler cards, Machine repair costs, Machine repair orders, Purchase ledger records. The more complete the shop system involved, the more numbering of machine tools becomes a matter of prime importance, and the more frequently these numbers are used. Since numbering often is done before much attempt has been made at system in other respects, it should be done in such a way as to accommodate any improvements in shop methods which may follow, without the necessity of revising the entire numbering scheme, which entails considerable work and confusion.

**133. Connecting machine numbers with the purchase invoice.** One of the most important things connected with numbering machine tools is to definitely connect the number with the purchase invoice, or with the record in the purchase ledger which itemizes the date of purchase, name of dealer, type of machine and price. When this is done, the manufacturer is fairly well protected against loss through fire, providing that he carries sufficient insurance for this purpose; for he will have no trouble making a proof of loss even without an appraisal. A common trouble is the loss of identity of a tool where this is not done, especially when several of the same size and type of machines have been purchased at various times, and the personnel of the shop has changed since their installation.

| NO. | MACHINE | SIZE | CAPACITY | MAKE | DEPARTMENT | PURCHASE LEDGER ITEM |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |

FIG. 33.—Card record of machine numbers.

To make sure of this connection, the machine number should start or originate with the purchase ledger entry, and also be entered upon the invoice itself. And in addition to the number given the tool by the purchaser, the manufacturer's number should also be entered as an additional precaution.

**134. Cross-indexing of machine numbers.** The method of ss-indexing machine-tool numbers varies with the system of

numbering employed, and will be described under the headings relating to various systems. Regardless of what method is used, the following information should be available. Knowing the type, name and size; the number of the machine. Knowing the number; the type, name and size. And, for price and dealer's name and similar information; knowing the machine number, the corresponding purchase ledger entry-number.

**135. Mnemonic machine-tool numbering.** Under this plan, various class symbols are combined with capacity or size symbols or figures into a composite term or total symbol which may represent the department, location in department, kind or type of machine, capacity, and the like. As in other applications of the mnemonic system, the aim is to make the symbol suggest its meaning as much as possible so that shop men can quickly become familiar with the symbols and use them in shop language instead of the common names of the articles symbolized.

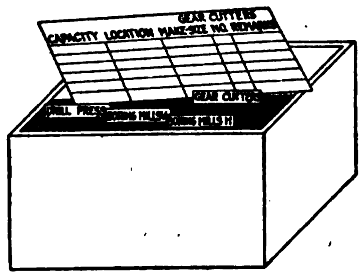


FIG. 34.—Cross index of equipment.

Thus, AMB–42 might represent the 42-inch boring machine in department A. If there were two of these, the symbol would have to be extended to AMB–42a, AMB–42b. When we get into these refinements, symbols become rather complicated, and it is a question if the plain numerical designation is not simpler in the long run.

*One advantage of the mnemonic system is the ease of indexing*, and the comparatively few cross-references needed, since the composite symbol when dissected into its key-components is self-explanatory. For example, the first letter might always represent the department, the second letter would be a key to the kind of machine, the third to its size. The reference index is, therefore, simply a key chart explaining the meaning of the various class symbols.

| Departments | Machines | Capacities |
|---|---|---|
| A = Heavy machine. | P = Planer. | Planers denoted by numerals representing distance between housings and travel. |
| B = Light machine. | L = Lathe. | Lathes represented by swing over ways and center distance. |
| C = Gallery No. 1. | T = Turret lathe. | |
| D = Gallery No. 2. | B = Vertical boring machine. | |
| | HB = Horizontal boring machine. | |

A few sheets of key letters, or class symbols, such as represented above, will furnish the clue to any number of combination symbols.

**136. Straight numeral numbering.** Using this plan, numbers are applied consecutively as the machines are purchased and installed, regardless of location, type of machine or other considerations. The disadvantage of the system is that the numbers furnish no clue to the location of the machine or its type. The advantage is

that this plan of numbering will never outgrow itself no matter how large the plant becomes. Cross-reference is necessary to furnish the information which the mnemonic system is designed to provide in the symbol. (See forms in Figs. 33 and 34.)

**137. Numbering by departments** may be done by providing consecutive department numbers for each department, starting with 1 in each case, as in straight numeral numbering. A modification of this is to provide the machine number with a prefix representing the department, as A-1, A-2, A-3; B-1, B-2, B-3. This plan is better, since it prevents having two or more similarly numbered machines in the same plant. The advantage of this plan over the straight numeral system is that it is never outgrown. The disadvantage lies in the transfer of machines from one department to another requiring a re-numbering of the machine and alteration of the records. The same system of indexes serves for this as for the above.

**138. Another scheme of numbering by departments is by the group number system.** Each department is assigned a set of numbers, sufficient to cover future needs, space being allowed between groups to take care of new purchases. For example, department 1 has the numbers from 1 to 200, although possibly but 20 or 30 machines are installed. Department 2 is assigned the numbers from 201 to 400. The disadvantage of this system is that it is almost invariably outgrown. The advantage is that the number gives the department key.

**139. Numbering by type of machine.** This is similar in plan, advantages and disadvantages to the system of numbering by departments, consisting of assigning group numbers to the various types of machines, such as planers, lathes, drilling machines. Sometimes the department letter is prefixed or added, in which case the only unknown quantity is the size of the machine, and the system approaches the mnemonic.

**140. Methods of putting numbers on the machines.** Stenciled numbers at least 2 inches high should be applied to the machines; either white or yellow paint being used for this purpose, so that the number is clearly visible from a distance. These numbers should be placed in corresponding positions on various types of tools; for example, on the housings of planers, on the legs or cabinets of lathes. Such symbols need frequent attention to keep them visible, becoming obscured through dirt, grease, etc., and sometimes intentionally.

In addition to the above a more permanent numbering plan is advisable. For this purpose the numbers do not need to be so large, 5/8 or 3/4 inch high being sufficient. Brass stamped plates can be bought with a series of consecutive numbers for this purpose, or the manufacturer can make his own number plates by using a large size pattern-letter embossing machine for this purpose and using brass tape instead of aluminum. When these embossed letters are used, to prevent the number becoming damaged by hammer blows it is advisable to fill the hollow spaces of the letters in the reverse side of the plate with solder before the plates are riveted to the machines.

**141. Inspection of machine numbers.** The condition of stenciled and permanent machine numbers should be made a part of equipment inspection.

## MACHINE LOCATION AND ARRANGEMENT

**142. Machine location.** The arrangement of machine tools and equipment within the plant to obtain the highest degree of efficiency is a difficult problem. It involves as much considerations as the general plan of manufacture, the scheme of transportation, stock and stores facilities, supervision, lighting, and drive. The effect of proper or improper location on general efficiency and cost of product it hard to estimate in dollars and cents, but there is no question that it is a large amount, possibly in some cases making the difference between profit and loss.

The extent to which machine location is governed by the actual steps in the process of finishing the product parts depends upon the class of work involved. A one-product shop is usually built around the paths of the product, all factors being designed to facilitate its movement. In a case of this kind, machine location is not as difficult as in the case of a plant having a considerable variety of work, since there are not as many factors entering into the question in the former case.

**143. The first step in planning machine location** in a new shop is to decide upon the general plan of manufacture. This is embraced in one of the following classifications: Concentration of product; concentration of machines; concentration of processes requiring similar degrees of accuracy; unit or group concentration; general or jobbing shop plan.

All of these plans may exist in one plant, but for a given section of any plant a definite plan may be chosen which will make the location of the equipment an easier problem, since certain principles may be followed to this end in each case.

**144. Concentration of product.** Particularly adapted to the one-product shop or department, or where the variety is not great. The essential feature of this plan is the grouping of various machines which must perform work on the product parts in such manner that the course of the work will be an easy uniform flow in as nearly a straight-line path as possible, and with as little back tracking as can be had. Transportation is the big consideration. The machines are therefore located chiefly with regard to the sequence of operations, more or less complicated drives being quite allowable to secure this feature. It is more difficult to take care of growth under this plan, owing to the fact that the entire equipment, which is balanced as much as possible with respect to production demands, is compressed into the least space consistent with ease of movement, and that an increase in production demands, as a rule, leaves no alternative other than overtime or a complete rearrangement. To a slight extent this condition may be met by leaving spaces alongside of those machines which experience shows will be the soonest to come up to capacity, but after this step is taken, and the business still increases, the same condition exists. Plants operating on "mass production" or large quantities in the lots going through

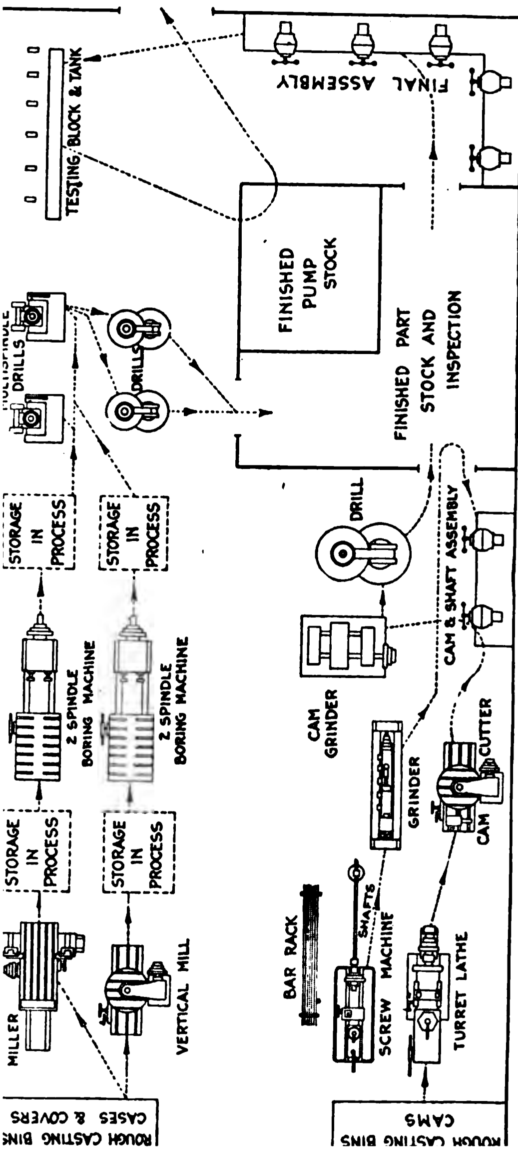



FIG. 35.—A department arranged on the plan of "concentration of product."

benefit most from the use of this plan. The first step is to analyze the operations required in great detail and use the results in arranging machines. Where a new department is planned to handle work that is already routed, the route cards are valuable for this purpose. Fig. 35 shows a layout according to this plan designed for a specific unit assembly, in this case a rotary pump such as is used as a circulating auxiliary pump. One size of this is built, and the arrangement is such as to facilitate the handling and cause the least retracing of paths.

**145. Concentration of machines.** Under this plan similar machines are grouped together in departments. Planers, millers, lathes, grinders, would be arranged without reference to the travel of the product, but with respect to ease of supervision and concentration of equipment. Where operating standards are worked out

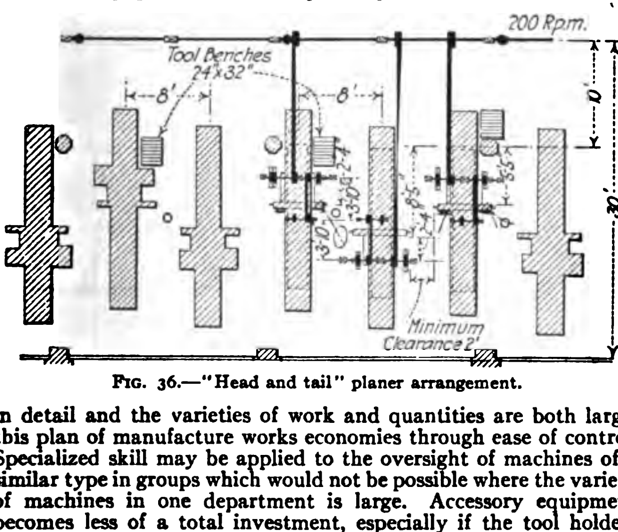



Fig. 36.—"Head and tail" planer arrangement.

in detail and the varieties of work and quantities are both large, this plan of manufacture works economies through ease of control. Specialized skill may be applied to the oversight of machines of a similar type in groups which would not be possible where the variety of machines in one department is large. Accessory equipment becomes less of a total investment, especially if the tool holders and spindle nose threads are standardized. Similar sizes and makes of machines are located together as much as possible for the same purpose.

Transportation is a minor feature with this plan, except between departments. Arrangement of stock rooms for handling the parts is an important item. The main consideration, however, is ease of machine operation and control.

L. P. Alford describes the methods of locating machines on the "one-shop" or concentration of machines plan in the American Machinist, vol. 30, p. 3, the plant described being that of the United Shoe Machinery Co. In all departments, tools are set far enough away from walls and windows to allow easy passage around them. No benches are placed against walls, cross benches being

given the preference. A main aisle 8 feet wide in the clear is maintained in each department, with cross aisles between blocks of machines. Each workman and machine is provided with a work-

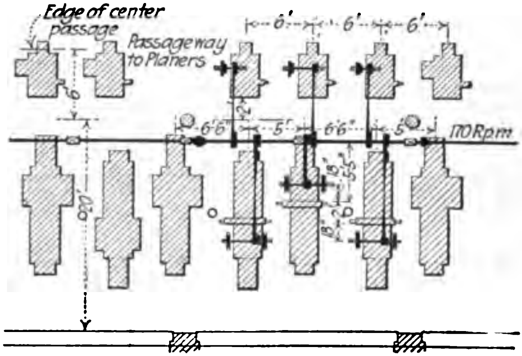



FIG. 37.—Minimum clearance for small planers and shapers.

table, and the location of these is considered when the machine layout is made.

Figs. 36 to 43 show typical machine group arrangements at this plant, clearance dimensions being given.

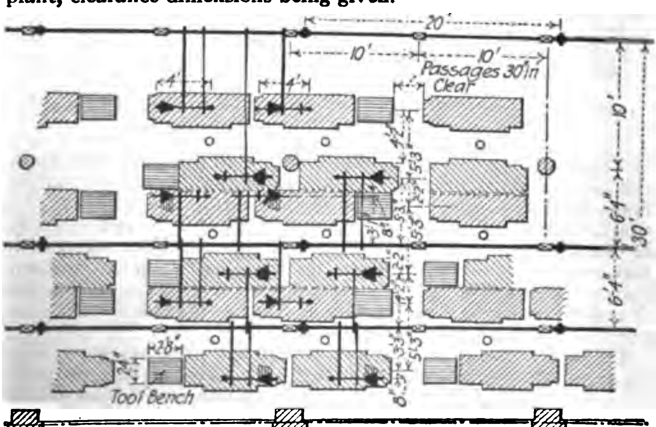



FIG. 38.—Minimum clearance for engine lathes.

It is noticed that many of the machines are arranged "head and tail" for double operation by one man. Another feature is the ngement of millers which has been found to work out admirably. gear cutters are arranged on the same plan.

**146. Concentration for accuracy.** In some plants there is a great difference in the degree of accuracy required not only between different machines built, but different integral parts of the same machine. It is a difficult thing to maintain a double standard of accuracy in one department. In one case the product will be too accurate but expensive, in another not accurate enough. Therefore

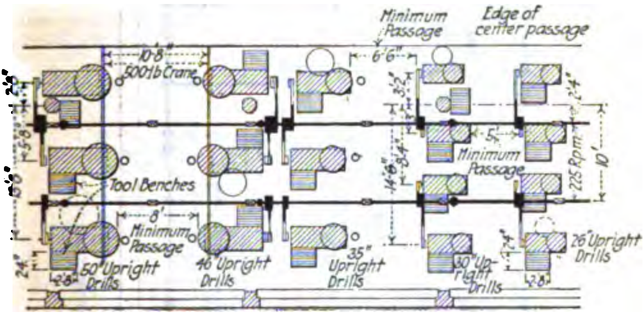



FIG. 39.—Arrangement of large upright drilling machines.

machines are sometimes arranged with the end in view of separating the cruder from the finer work.

**147. Unit, or group concentration.** A modification in which certain classes of parts are handled in grouped sub-departments whose construction is according to concentration of machines but

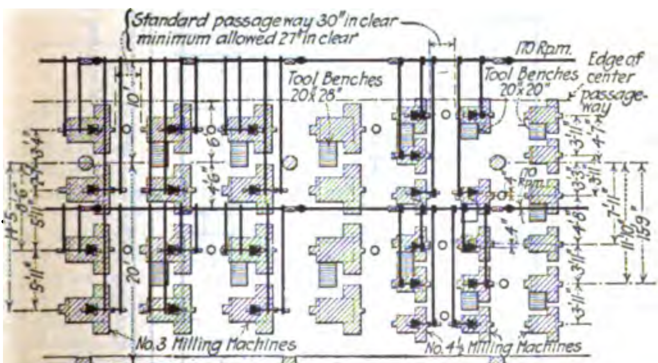



FIG. 40.—Minimum clearance for milling machines.

the groups themselves being arranged more or less on lines of concentration of product. This plan is much older than the modern names applied to describe it, in many shops it is the natural arrangement resulting from numerous shifts to suit the work handled.

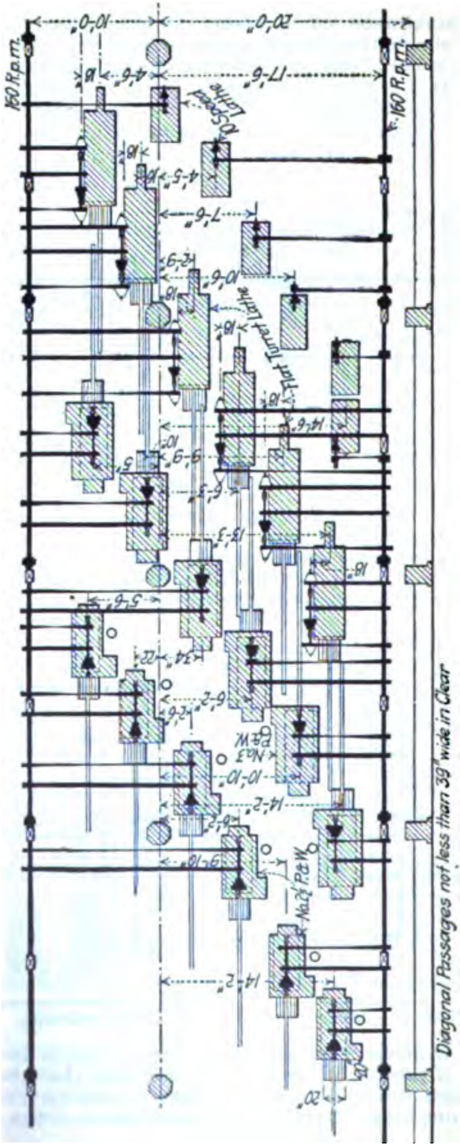



FIG. 41.—Minimum clearance for hand screw machine.

**148. Another modification of the group plan** on opposite lines is that where unit assemblies are machined and constructed in grouped departments according to concentration of product as far as the complete unit is concerned, after which, or aside from which other plant arrangements are in use. This also dates back considerably beyond the term "unit assembly," it being a natural plan to segregate similar constructions as evidenced by the "air-brake" and other similar departments in railroad shops, generally designated by the name of the unit worked upon.

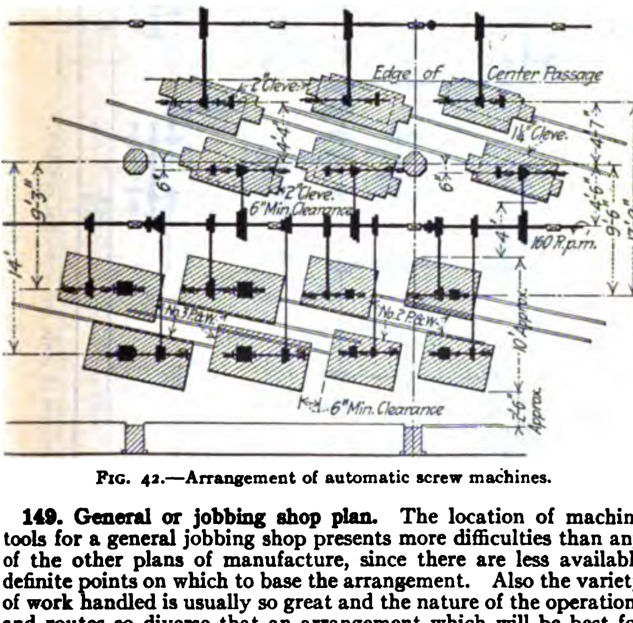



FIG. 42.—Arrangement of automatic screw machines.

**149. General or jobbing shop plan.** The location of machine tools for a general jobbing shop presents more difficulties than any of the other plans of manufacture, since there are less available definite points on which to base the arrangement. Also the variety of work handled is usually so great and the nature of the operations and routes so diverse that an arrangement which will be best for one part will usually be as correspondingly bad for another. The only thing to do in this case is to strike an average which will present the most points of advantage and the least disadvantages. Points to be considered are: (*a*) The least back tracking of heavy parts in their course through the shop. This necessitates locating the first operation heavy machines, such as planers and boring mills as near the foundry door as possible.

(*b*) Concentration of the light machines in groups as far as possible, under the plan of concentration of machines, for ease of control and interchangeability of equipment.

(*c*) Plenty of department storage space for large castings, unless separate storage departments are provided, so that work in process and delayed may not require additional handling.

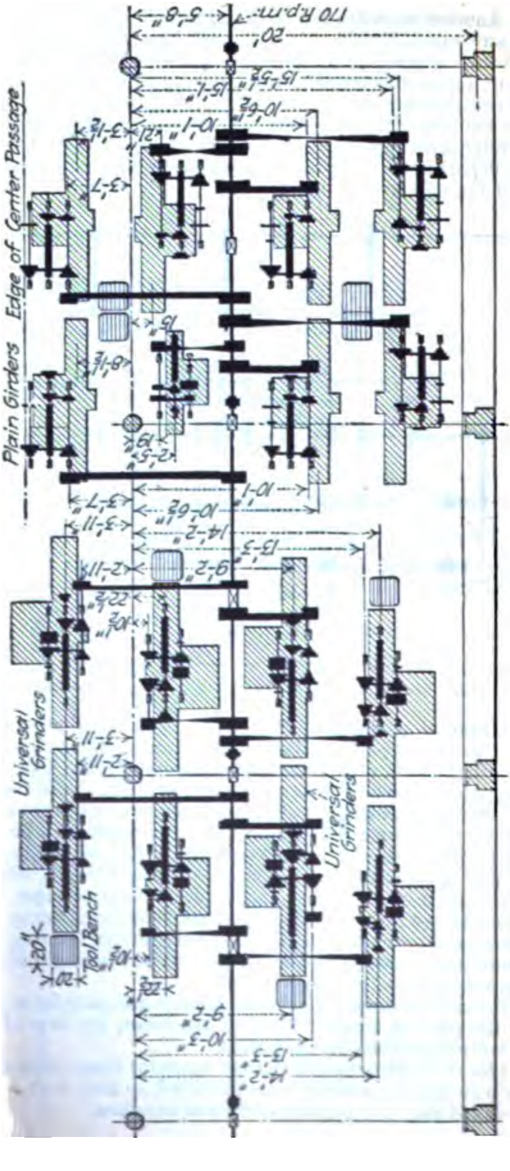



FIG. 43.—Arrangement of plain and universal grinders.

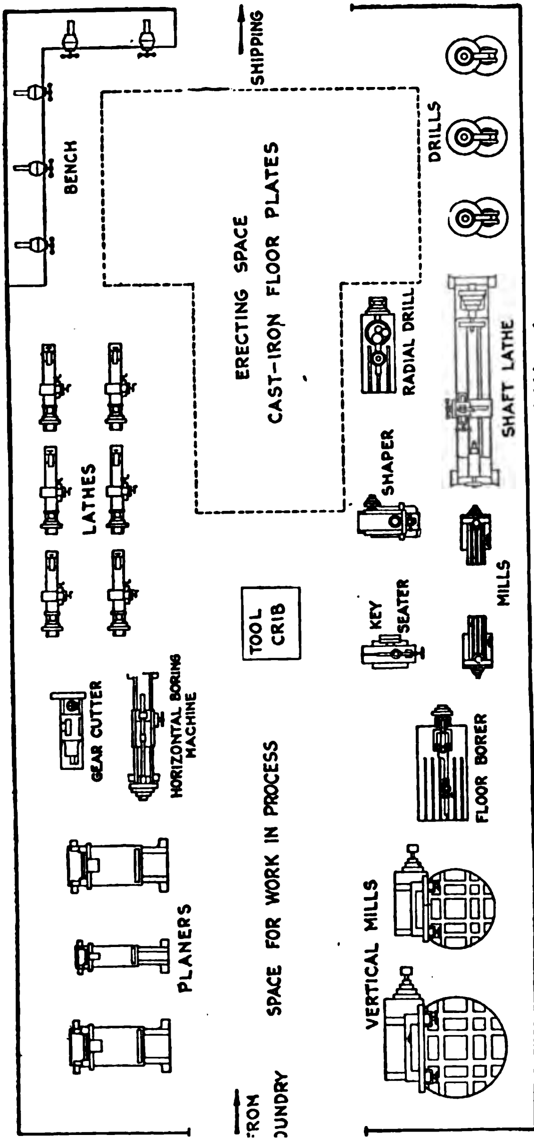



Fig. 44.—Typical arrangement of machines in a jobbing shop.

(*d*) Truck space available for the storage of smaller parts in process upon trucks, so that they will not have to be rehandled. The moving of the trucks themselves is much less of an item than the loading and unloading.

(*e*) Aisles which permit of truck passage, double truck clearance being allowed on main aisles.

(*f*) Arrangement of machines for simplicity of drive, and lighting.

The plan shown in Fig. 44 represents a layout for a small jobbing shop.

**150. Graphical methods of locating machines.** The general method employed in locating and rearranging machines within a given space is illustrated in Fig. 45. An outline drawing is prepared to scale, showing the space in question, location of posts,

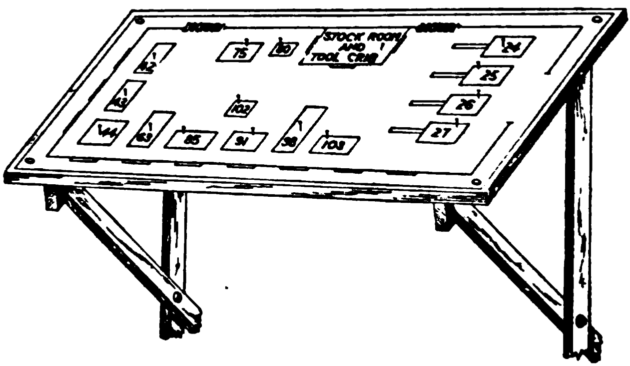



Fig. 45.—Graphical method of locating machine tools.

windows and other important structural features. The various machines are laid out on paper, to the same scale, the overall lengths and widths being shown, care being taken that full traverse of tables is accounted for. These are then cut out, and may be arranged and rearranged as often as desirable, until the best solution is found. To keep track of different arrangements, a good plan is to make the machine cut-outs on darker shade paper, and then photograph the whole. Common pins or thumb tacks are used to hold the slips in position upon the drawing.

A plan of this size for convenience requires to be carried out on a comparatively large scale, anything less than ¼ inch to the foot being too small for convenient handling. After the machines are located to best advantage as far as the principles looked for are concerned, the matter of drive may be gone into and planned. It is a good plan to remember that the more that belt pull on the line shaft is equalized by placing equal amount of tension on both sides, the less will be the line friction, which as a rule is quite a large per-age of the total load. This is a minor consideration, but should ept in mind to make the most of it where possible.

## POWER REQUIRED BY VARIOUS TOOLS

### 151. Power required by various machine tools.

**Power Values for Machine Tools in Groups**

| Kind | Size | Observed horse power, maximum | Observed horse power, average | Remarks |
|---|---|---|---|---|
| BORING MACHINES: | | | | |
| Bullard, single head | 36 in. | 0.78 | 0.52 | |
| Bullard, double head | 42 in. | 1.72 | 1.08 | |
| CAM CUTTERS: | | | | |
| Brainard | No. 2 | .......... | 0.67 | |
| Brainard | No. 4 | 0.48 | 0.32 | |
| Brainard | No. 5 | 0.48 | 0.32 | |
| Lathe type, single head | .......... | .......... | 0.32 | |
| Lathe type, double head | .......... | .......... | 0.50 | |
| CUTTING-OFF MACHINES: | | | | |
| Hurlbut-Rogers | 1 15/16 in. | .......... | 0.12 | |
| Hurlbut-Rogers | 2 in. | 0.28 | 0.14-0.18 | |
| Hurlbut-Rogers | 3 in. | 0.34 | 0.20-0.22 | |
| DRILLING MACHINES: | | | | |
| Prentice Bros. radial | No. 0 | .......... | 0.72 | |
| Prentice Bros. radial | No. 1 | 3.18 | 1.12 | |
| Woodward & Rogers | Sensitive single-spindle | .......... | 0.31 | |
| Dwight-slate | 2-spindle | | 0.32 | |
| Woodward & Rogers | Sensitive 3-spindle | .......... | 0.35 | |
| Woodward & Rogers | 4-spindle | .......... | 0.48 | |
| Woodward & Rogers | 6-spindle | .......... | 0.71 | |
| Prentice upright | 16 in. | .......... | 0.25 | |
| Prentice upright | 18 in. | .......... | 0.35 | |
| Prentice upright | 20 in. | .......... | 0.42 | |
| Prentice upright | 22 in. | .......... | 0.59 | |
| Blaisdell upright | 24 in. | .......... | 0.47 | |
| Blaisdell upright | 26 in. | .......... | 0.22 | |
| Blaisdell upright | 28 in. | .......... | 0.25 | |
| Blaisdell upright | 30 in. | .......... | 0.30 | |
| Blaisdell upright | 34 in. | .......... | 0.45 | |
| Blaisdell upright | 36 in. | .......... | 0.53 | |
| Blaisdell upright | 46 in. | .......... | 0.63 | |
| Blaisdell upright | 50 in. | .......... | 0.83 | |
| GEAR CUTTERS: | | | | |
| Brainard | No. 4½ | .......... | 0.15-0.32 | |
| Gould & Eberhardt | No. 3 | .......... | 0.20 | |
| Brown & Sharpe | No. 3 | .......... | 0.20 | |
| GRINDERS: | | | | |
| Brown & Sharpe cutter and reamer grinder. | No. 3 | .......... | 0.32 | |
| C. H. Besly & Co. Gardner grinder. | No. 4 | 1.42 | 0.53 | |
| Brown & Sharpe plain | No. 11 | .......... | 0.80 | |
| Brown & Sharpe surface. | No. 2 | .......... | 0.40 | |
| Brown & Sharpe surface. | No. 3 | .......... | 0.50 | |
| Brown & Sharpe universal | No. 1 | .......... | 0.60 | |
| Brown & Sharpe universal | No. 2 | .......... | 0.76 | |
| Diamond wet tool grinder | .......... | 3.29 | 0.97 | Carrying one 20-in. wheel |
| Leland & Faulconer wet grinder. | .......... | .......... | 0.41-0.82 | Carrying two 24-in. wheels |

**Power Values for Machine Tools in Groups.**—*Continued*

| Kind | Size | Observed horse power, maximum | Observed horse power, average | Remarks |
|---|---|---|---|---|
| DROP HAMMERS: | | | | |
| Blondell | 40 lb. | .......... | 0.10 | |
| Pratt & Whitney | 250 lb. | .......... | 2.00 | |
| Pratt & Whitney | 400 lb. | .......... | 2.50 | |
| Pratt & Whitney | 600 lb. | .......... | 3.00 | |
| Pratt & Whitney | 800 lb. | .......... | 3.50 | |
| Pratt & Whitney | 1000 lb. | .......... | 4.00 | |
| Billings & Spencer | 1500 lb. | .......... | 5.00 | |
| POWER HAMMERS: | | | | |
| Bradley | 100 lb. | .......... | 1.50 | |
| Bradley | 150 lb. | .......... | 1.75 | |
| KEYSEATER: | | | | |
| Baker Bros | No. 4 | 0.64 | 0.28–0.32 | |
| LATHES: | | | | |
| Reed boring lathe | 20 in. | .......... | 0.35 | |
| Reed boring lathe | 30 in. | .......... | 0.41 | |
| Reed engine lathe | 12 in. | .......... | 0.24 | |
| Reed lathe | 14 in. | 0.48 | 0.26 | |
| Prentice | 16 in. | .......... | 0.34 | |
| Reed | 16 in. | .......... | 0.36 | |
| Blaisdell | 18 in. | .......... | 0.39 | |
| Blaisdell | 20 in. | .......... | 0.44 | |
| Reed | 22 in. | 0.37 | 0.32 | |
| Reed | 24 in. | .......... | 0.25 | |
| Blaisdell | 24 in. | .......... | 0.31 | |
| Prentice | 28 in. | .......... | 0.31 | |
| Draper | 38 in. | .......... | 0.58 | |
| Reed speed lathe | 10 in. | .......... | 0.10 | |
| Reed speed lathe | 14 in. | .......... | 0.12 | |
| Putnam squaring-up lath | 15 in. | .......... | 0.25 | |
| Gisholt turret lathe | Size H | .......... | 0.70 | |
| Potter & Johnston semi-automatic. | No. 1 | 1.63 | 0.33–0.63 | |
| Jones & Lamson flat turret. | 2×24 in. | 1.97 | 1.20–1.80 | |
| Wood turning lathe | 14 in. | .......... | 0.31 | |
| Wood turning lathe | 16 in. | .......... | 0.36 | |
| Wood turning lathe (Putnam gap). | 36 in. | 1.50 | 1.30 | |
| MILLERS: | | | | |
| Brainard | No. 1 | 0.47 | 0.30 | |
| Brainard | No. 3 | 0.64 | 0.26 | |
| Brainard | No. 4 | .......... | 0.19–0.29 | |
| Brainard | No. 4½ | .......... | 0.13–0.19 | |
| Brainard | No. 6 | .......... | 0.26 | |
| Brainard | No. 7 | .......... | 0.83 | |
| Brainard | No. 14 | .......... | 0.25 | |
| Brainard | No. 15 | .......... | 0.25 | |
| Becker vertical | No. 3 | .......... | 0.26 | |
| Becker vertical | No. 5 | .......... | 0.55 | |
| Becker-Brainard | No. 3 | .......... | 0.17–0.25 | |
| Brown & Sharpe | No. 1 | .......... | 0.15 | |
| Brown & Sharpe | No. 2 | .......... | 0.25 | |
| Brown & Sharpe | No. 5 | .......... | 0.30 | |
| Reed | No. 7 | .......... | 0.83 | |
| Pratt & Whitney hand | No. 1½ | .......... | 0.20 | |

**Power Values for Machine Tools in Groups.**—*Concluded*

| Kind | Size | Observed horse power, maximum | Observed horse power, average | Remarks |
|---|---|---|---|---|
| PLANERS: | | | | |
| Whitcomb | 17 in. | 2.01 | 1.00–0.43 | |
| Whitcomb | 22 in.× 5 ft. | 2.34 | 1.16–0.53 | |
| Putnam | 22 in.× 5 ft. | 1.44 | 0.70 | |
| Putnam | 24 in.× 6 ft. | .......... | 0.84 | |
| Putnam | 26 in.× 5 ft. | 1.59 | 0.81 | |
| Putnam | 30 in.× 6 ft. | 4.91 | 1.31 | |
| Putnam | 30 in.× 8 ft. | 5.46 | 1.56 | |
| Powell | 36 in.×10 ft. | 4.00 | 1.60 | |
| Pond | 50 in.× 9 ft. | 2.94 | 1.14 | |
| Wood panel planer | 34 in. | 7.75 | 3.70 | |
| Wood surface | 24 in. | 3.40 | 2.00 | |
| POLISHING STANDS: | | | | |
| Brown & Sharpe | No. 3 | .......... | 1.00 | |
| Diamond | No. 5 | .......... | 1.19 | |
| PUNCH PRESSES: | | | | |
| Bliss | No. 3 | 2.59 | 1.26 | |
| PROFILING MACHINES: | | | | |
| Garvin | No. 1 | .......... | 0.50 | |
| Pratt & Whitney | No. 6 | .......... | 0.40 | |
| BAND SAW: | | | | |
| Fay & Co | 36-in. wheels | 3.00 | 0.87 | Used for pattern work. |
| CIRCULAR SAWS: | | | | |
| Kimball Bros | 9-in. blade | 3.77 | 1.05 | |
| Whitney | 9-in. blade | 3.75 | 1.04 | |
| White | 13-in. blade | 5.82 | 1.21 | |
| HACK SAW: | | | | |
| .......... | 12 in.–14 in. | .......... | 0.06 | |
| SCREW MACHINES: | | | | |
| Brown & Sharpe automatic. | No. 1 | .......... | 0.60 | |
| Pratt & Whitney automatic. | No. 2 | .......... | 0.37 | |
| Pratt & Whitney | No. 2 | .......... | 0.72 | |
| Pratt & Whitney | No. 3 | .......... | 0.80 | |
| Brown & Sharpe automatic. | No. 3 | .......... | 0.80 | |
| Pratt & Whitney automatic. | No. 3-O | 1.04 | 0.90 | |
| Pratt & Whitney | No. 3-B | 1.04 | 0.90 | |
| Brown & Sharpe | No. 00 | .......... | 0.36 | |
| Cleveland | 7/8 in. | .......... | 0.40 | |
| Cleveland | 2 in. | .......... | 0.87 | |
| Cleveland | 2¼ in. | 1.04 | 0.90 | |
| Pratt & Whitney hand | No. 2 | .......... | 0.43 | |
| Pratt & Whitney hand | No. 2½ | .......... | 0.47 | |
| Pratt & Whitney hand | No. 3 | .......... | 0.50 | |
| SHAPERS: | | | | |
| Lodge & Davis | 14 in. | .......... | 0.35 | |
| Hendey | 20 in. | .......... | 0.50 | |
| Hendey | 24 in. | .......... | 0.52–0.70 | |
| Hendey | 28-in. | .......... | 0.52–0.70 | |
| TAPPING MACHINE: | | | | |
| Pratt & Whitney | No. 2 | .......... | 0.10 | |

## Sizes of Motors for Engine Lathes

| Swing in inches | Horse power for light duty | Horse power for medium duty | Horse power for heavy duty |
|---|---|---|---|
| 14 | 2 | 3 | 5 |
| 16 | 3 | 5 | 5 |
| 18–20 | 3 | 5 | 7½ |
| 22–24 | 5 | 7½ | 10 |
| 27–30 | 7½ | 10 | 15 |
| 36–48 | 7½ | 10 | 20 |

## Sizes of Motors for Planers

| Size in inches | Horse power for medium duty | Horse power for heavy duty |
|---|---|---|
| 24 × 24 | 5 | 7½ |
| 30 × 30 | 7½ | ...................... |
| 36 × 36 | 10 | ...................... |
| 42 × 42 | ...................... | 25 |
| 48 × 48 | 15 | ...................... |
| 56 × 56 | 15 | 30 |

## Sizes of Motors for Shapers

| Size in inches | Horse power |
|---|---|
| 14–20 | 3 |
| 24 | 5 |
| 26 | 7½ |

## Sizes of Motors for Crank Slotters

| Size in inches | Horse power, light duty | Horse power, medium duty |
|---|---|---|
| 10 | 3 | 5 |
| 10–16 | 5 | 7½ |
| 20 | 7½ | 10 |
| 26–30 | 15 | ...................... |

## Sizes of Motors for Millers

| Table feed in inches | Cross feed in inches | Vertical feed in inches | Horse power for medium duty |
|---|---|---|---|
| 24 | 8 | 18 | 3 |
| 30 | 10 | 18 | 5–7½ |
| 36 | 12 | 20 | 7½–10 |
| 50 | 12 | 20 | 10–15 |

## Sizes of Motors for Vertical Millers

| Table diameter in inches | Spindle diameter in inches | Horse power |
|---|---|---|
| 28 | 4 | 5 |
| 32 | 4 | 7½ |
| 40 | 4½ | 10 |
| 54 | 5 | 15 |
| 70 | 6 | 20 |

### Sizes of Motors for Vertical Drilling Machines

| Size in inches | Horse power |
|---|---|
| Friction | 1/4 |
| 15 | 1/2 |
| 20–26 | 1 |
| 28–34 | 2 |
| 40–50 | 3 |

### Sizes of Motors for Radial Drilling Machines

| Length of arm in feet | Horse power |
|---|---|
| 4 | 3 |
| 5 | 5 |
| 6 | 5 |
| 10 | 7½ |

### Sizes of Motors for Vertical Boring Machines

| Size in inches | Horse power |
|---|---|
| 24–30 | 5 |
| 36–42 | 7½ |
| 60–90 | 10 |
| 100 | 15 |
| Feet | |
| 10 | 20 |
| 12 | 20 |
| 14 | 25 |
| 16 | 30 |

### Sizes of Motors for Cylindrical Grinders

| Size in inches | Horse power for medium duty | Horse power for heavy duty |
|---|---|---|
| 10 × 50 | 5 | 7½ |
| 10 × 72 | 5 | 7½ |
| 10 × 96 | 5 | 7½ |
| 10 × 120 | 5 | 7½ |
| 14 × 72 | 10 | 12 |
| 18 × 96 | 10 | 15 |
| 18 × 120 | 10 | 15 |
| 18 × 144 | 10 | 15 |
| 18 × 168 | 10 | 15 |

### Sizes of Motors for Cold Saws

| Diameter of saw in inches | Thickness of saw in inches | Horse power |
|---|---|---|
| 12 | 5/32 | 2 |
| 15 | 5/32 | 2 |
| 18 | 3/16 | 3 |
| 20 | 3/16 | 3 |
| 24 | 3/16 | 5 |
| 32 | 3/16 | 7½ |
| 36 | 3/16 | 10 |

As an indication of the possibilities of power saving in this respect, the following by L. P. Alford in the American Machinist will be of interest.

| | |
|---|---|
| Percentage of friction load to total load | 44.6 |
| Percentage friction load of prime mover to total load | 3.7 |
| Percentage main shafts and main belts to total load | 3.1 |
| Percentage distributing shafts and machine tool countershafts and belts | 37.8 |

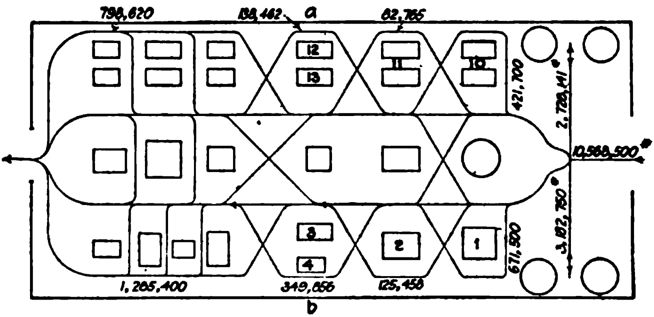



FIG. 46.—Graphical method of laying out transplantation routes.

A comparison of the sides $A$ and $B$ indicates that traffic is much more dense on the latter side. Better distribution will be had if machines 1, 2, 3 and 4 are placed on side $A$ and 10, 11, 12 and 13 are brought to side $B$. This same method of analysis is particularly effective in solving interdepartment or building transportation problems. Figures representing relative transportation values or "transportation factors" are obtained from the route cards of the principal product parts, infrequently manufactured parts being omitted. The cards representing the "principal paths" are segregated, the sales statistics for the parts and the weight of parts obtained. The product of quantities multiplied by weights gives the weight factor, and indicates the amount of traffic. The product of the above multiplied by length of path gives a "weight-distance factor" which bears close relation to the cost of transportation.

*Example:*
Route 15

| Parts | Quantities | Weights | Weight factor |
|---|---|---|---|
| 2*B*4 | 2000 | 14 | 28,000 |
| 2*B*6 | 3440 | 125 | 430,000 |
| *NM*14 | 1224 | 60 | 73,400 |
| Density of traffic on Route 15 | | | 531,400 |

## TOOL-ROOM METHODS

**152. Tool-room production systems.** The tool department is often thought of as a thing apart from the ordinary conditions of routine and system applied to the direct or producing departments and not to be hampered by ordinary restrictions on account of a possible injury to the quality of the work produced. Common sense can be applied here, however, to the benefit of the quality of the work as well as its cost. The following comparison illustrates some points of difference between an inefficient and an efficient tool production system.

| Inefficient Tool-room System | Efficient Tool-room System. |
|---|---|
| No standards. | Adoption of standard parts whereever possible, and complete tabulations of standards. |
| Tools designed by the foreman. | Tools designed by an expert tool-designer after careful study. |
| Crude drawings leaving practically all detail to the tool-maker. | Well executed drawings containing all necessary information as to construction, dimensions and degree of accuracy. |
| Verbal orders. | Written production orders. |
| No serial or tool numbers. | Serial numbers for each job, contained on the production order. |
| Congestion and confusion of work. | Carefully planned work. |
| No costs obtained on individual tools, or at best inaccurate ones. | Accurate costs on each serial number. |
| Everything done in the tool room, even to making screws. Bushings and small parts made one at a time as required. | Standard bushings, screws and small parts made in large quantities in the productive departments, on screw machines or automatics. |
| Each jig and tool built complete by one man who handles it from start to finish, lays out, runs the various machine tools, does the hardening, assembles, tests. | Division of labor in the tool room according to the degree of skill required. One man for laying out and locating; individual operators for the department tools; assemblers and fitters who are specialists; one man in charge of the hardening; a man who makes the operating tests. |
| No inspection. Tool maker's word taken for results until complaints are are made by users of tools. | Complete inspection with a record of results. |
| *Results:* Perhaps a good tool, certainly a costly one. | *Results:* A first-class tool at a low cost. |

**153. Numbering of minor equipment.** Jigs and tools are sometimes numbered under the mnemonic system. When this is the practice the symbol usually becomes quite complicated. It seems as if the mnemonic system were an unnecessary refinement as applied to such equipment, since the symbols are not left to memory but are always placed on the instruction cards. When this is the case, a plain number is just as convenient although possibly not as impressive.

A combination of the mnemonic and the plain serial system of numbering is sometimes used. Thus a prefix letter such as *J., F.* or *T.* would indicate whether the article described was a jig, fixture or tool. The serial number would follow it.

*The numbers stamped upon tools and jigs* should be sufficiently large and should preferably be stamped in two places so that if one becomes disfigured the identity of the tool is not lost. Letters and figures ¼ inch high should be the minimum, except on very small tools and jigs where there is not room for them.

Final inspection of tools and jigs should include making sure that they are properly numbered.

The numbering of minor equipment also includes the subject of numbers for benches, vises, cupboards, worktables, tool racks and the like. In almost all cases these are numbered serially. *Book records are kept of the numbers* containing description of the apparatus, sometimes with prices attached. In fact every piece of equipment within the plant should have a number, exclusive of the standard small tools.

**154. Tool records.** Tool records are necessary to prevent loss of tools. There are several kinds of records kept, varying with the kind of tools used. The purchase ledger entries for small tools such as drills, taps, reamers and dies, will be sufficient for this class, in combination with the tool checks that are used to control their issue.

*Special tools are numbered,* as are also jigs and fixtures, and sometimes the more expensive standard tools such as large size inserted-tooth cutters are numbered also. In cases of this kind a book record of numbers is necessary, each number being followed by a description of the tool and its uses, if purchased or made, and sometimes its cost.

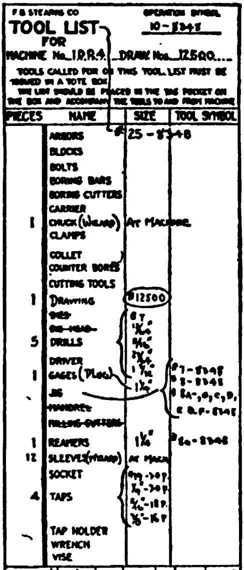



Fig. 47.—Tool list to accompany a set of tools.

*Card records of tools* which are issued in sets are also kept, as shown in Fig. 47. Card records are also used to inform the drafting department and the tool designer of the available tools so that unnecessary or odd sizes and designs may be eliminated.

**155. Tool inventory.** Since the major part of the contents of the tool room is recorded in permanent record form, the taking of an inventory is a simple matter in this department. The standard tool record may be used providing it is kept up-to-date and discarded tools are properly noted.

*Unrecorded tools* such as small standard tools must be inventoried, at least such as are in use. The reserve tool stock of this description being kept in locked cupboards in the original packages presents no difficulty in this respect. It is usual to recall all tools to the tool room and tool cribs just before inventory is taken.

*The inventory of tool steels* presents the greatest difficulty on account of the many varieties in use. To make this matter more simple it is necessary to see that each tool issued is stamped with the make of steel composing it. The same thing applies to marking steel bars in stock. Sometimes a color is selected to represent each brand and the bars are striped with paint their entire length as soon as received. More permanent method consists of stamping the initials of the make every 6 inches on the bar. Inventory of tool steel is by weight, but the weights are proportional to the lengths for a given size, which gives an easier method of arriving at the value. A quantity of tool-steel bars may be measured without removing them from the rack providing the bars are flush at one end and measurements are made from a standard length at the other.

**156. Tool costs.** Individual tool costs are essential to properly control the operation of this department and also to find if it pays to build certain tools, or buy them. These costs need not be itemized to any great extent as regards operations or parts, as would be done on direct costs. A simple way is to carry total charges against the tool numbers, no tool being built without a number. Space should be provided on the order for tools which also contains the tool number, for the purpose of noting the material that was used to arrive at a material cost.

**157. Surplus tool stock.** The surplus tool stock may well be kept in the stores department, and requisitioned from there by the tool-room foreman when required. This not only gives more room in the tool department but provides an additional check upon tool consumption. This applies particularly to purchased standard small tools.

**158. Jig and fixture storage.** The methods of storing jigs and fixtures varies with the physical arrangement of the plant. Where the central tool room is easily accessible to all departments, they are often kept there, especially when good transportation delivers them with the required tools to the machine.

Where tool cribs are used to reduce transportation, it is quite usual to employ department storage of the jigs and fixtures, since their weight makes transportation an important consideration. No matter where located the jig storage should be arranged to keep the jigs away from the floor and as free from dampness and dust as possible. Especial attention should be given to preventing dust from grinding wheels settling upon them. *Direct responsibility for jigs in storage* should be assigned to some one and it should be his duty to see that the finished parts such as bushings and locating points are properly protected against rust by slushing with oil.

**159. Tool and jig inspection.** To maintain the accuracy of the product it is necessary to insist upon the proper inspection of cutting tools and also of jigs and fixtures. The former should be inspected both upon their return and before being issued, the latter may be inspected at longer intervals. *Direct responsibility for the inspection* of cutting tools makes it easy to place the blame if a tool is found cutting over or under size. No record is usually kept of the inspection of jigs and fixtures but it is sometimes the practice to make a note of the jig number and date of inspection and whether O. K. or requiring repairs.

**160. Grinding tools in the tool room, versus in the shop.** At present the question of the advisability of grinding all tools and issuing them from the tool department is a disputed one. The advisability depends on shop conditions, nature of the skill employed, and so on. A temporary information system installed for the purpose of finding out how much time the producers and their machines lose on account of grinding tools may throw light on the question. In this connection, the use of machine hour rates is helpful, as it indicates how much each machine is worth per hour to the plant, including the operator's rate as well.

If the tools are to be ground by the individual mechanics, proper wheels should be provided and kept in condition by frequent truing

up. Wet wheels through carelessness or accident to the pumping apparatus are often allowed to run as dry wheels and ruin many tools before they start cutting. In addition to keeping the wheels in proper condition, they should be spaced at frequent intervals and so distributed through the shop that a minimum distance will have to be traversed by the operators in going from the machines to the wheels. Where duplicate wheels are provided and the wheel is within easy reach of the machine, it is not necessary to shut down the machine to grind, and therefore no time is lost under these conditions. *Clearance angle gages* are sometimes provided at the wheels, so that the operators may approximate uniform angles, which is difficult to do without a gage.

If the tools are to be ground in the tool department, or in tool cribs, and there is enough of them to grind, say to supply 40 or 50 machine tools, it will be advisable to install a tool grinder which will reproduce any desired angle of cutting edges. It is unnecessary to state that twist drills and roughing reamers should be ground only on drill grinders, as it is almost impossible as well as a waste of time to attempt to equalize the length of the cutting lips or their angles when grinding by hand. The grinding of tools in the tool department makes it necessary to first standardize the shapes, sizes and proportions of the cutting tools in use in the shop as otherwise their variety would be so great as to make it impossible to handle them on a machine.

**161. Operating a central tool grinding department.** The first and a necessary step toward operating a central tool grinding department consists in a standardization of the forms of cutting tools which are to be handled there. In the average shop there are almost as many shapes of tools as there are mechanics who use them, far too great a number of shapes to be taken care of in a central department. Lathe tools have been fairly well standardized, there is a lack of data on other tools, however. *A good plan is to select a committee* to pass upon the forms which shall be adopted as standard, since the nature of the work will determine this to some extent. Under this proceeding, the mechanic has opportunity to explain the necessity of certain shapes which he may have found to advantage for particular jobs, and which an arbitrary decision as to standards would eliminate, possibly to the consequent loss of profits. See also 177.

It will be found that certain tools will have to remain special, and for use on certain machines only. A compromise may be effected by allowing them to remain at the machine, considering them as special equipment, just as machine attachments would be considered.

Assuming that a certain number of shapes and sizes have been selected as standard, it is necessary to provide a sufficient supply of each so that there will be no delays on account of lack of ground tools ahead. The number will depend upon the probable use of the tool and the number of machines using the same type. It is better to have too many than not enough, since they will be well cared for under this scheme. The length of time that a tool will last without regrinding should not be taken as over 1 hour. Where consider-

able roughing is done on hard cast iron with scale, this will have to be reduced.

The next step is to arrange a *system of symbols* or numbers by which the tools may be known. If a mnemonic system is contemplated, the symbol should comprise elements relating to the size and shape of tool, and for what machine. Thus, 1½*RLC*. might serve to indicate a 1½-in. standard round-nose lathe tool, ground for cast iron. Whatever system of designating them is employed, a key or chart should be provided for the use of the mechanics and especially of new men who are not familiar with the symbols; unless instruction cards are in full use which give the symbols of the tools to be used.

*A checking system* must be employed in connection with the tool issue. The tool-check system which is in force may usually be adapted to this. However, it is advisable to have the operator provided with reserve supply, so that production will not be retarded

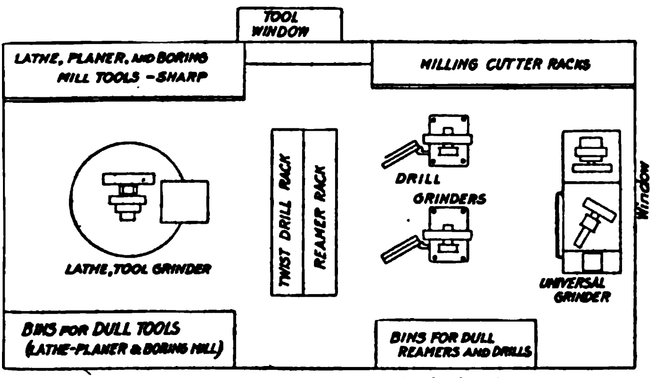



FIG. 48.—Arrangement of a central tool grinding department.

when a tool becomes dull. There would be nothing gained, and considerable lost for example if one tool was issued and returned at a time. The rule should be enforced, however, that dull tools must be returned promptly in order that the grinder operator may not be handicapped by his stock running low and a large quantity of dull tools held out. Tool boys are properly used for this service.

Racks are provided in the tool department for ground tools. Bins are provided for the dull tools, the operator being able to judge by the relative amount of sharp and dull tools when it becomes necessary to grind a particular type. When tool grinders are used, as they almost invariably are with central tool-grinding departments, the angles to which the machine is to be set for a given tool is conveniently marked upon the bin containing it.

Where the shop is not large enough to keep one man going on lathe, planer or boring machine tools, a combination may be effected by hiring a man who is also able to operate a universal grinder, and keep him busy at odd times in connection with the milling cutters

or productive grinding jobs when these are not available. A layout of a typical grinding department organized on these lines is indicated in Fig. 48. In this case the operator of the grinders also takes charge of issuing and checking such tools as are given out in his particular line.

**162. Tool cribs.** The issuing of tools from the tool room or tool-making department is quite common in small shops, where these two functions are combined, often with no physical separation between those engaged in making and repairing tools, and the supply of small tools. There is quite a temptation involved in this, and it requires taking a big chance as to the honesty of every employee who has access to the department. A separation of the tool supply and stock from the tool room is highly desirable, and the cost of the necessary partition which is usually made of heavy wire screening is a small premium to pay for insurance against loss. Under these conditions the tool tender can be made responsible for the material under his charge, and it is possible to have a close check on its consumption.

Machine....3 Mx
Part........4B
Operation...Drill, ream and tap
Blue-print...406–45

Tool List

1—$\frac{1}{4}$-in. s.s.h.s. drill
1—Magic chuck 3 shank
1—3 to 4 adapting bushing
1—1 $\frac{3}{16}$ flat twist drill
1—1 $\frac{1}{4}$ machine reamer
1— $\frac{5}{8}$ h.s. drill
1—$\frac{3}{4}$ u.s.s. R.H. tap.

Tools must be returned in the same tote box that they are issued in.

FIG. 49.—A tool list covering a set of tools for a drill press operation.

When a shop comprises several departments, or consists of several floors, it becomes quite a loss to have the mechanics take the time to go to the tool room after tools. Compromises are then effected, sometimes by having tool boys who come in response to annunciator signals, get the check and the tool order, and secure the tool and deliver it. Another scheme is to provide supplementary tool cribs in the various departments, containing those tools which are most commonly used. This usually necessitates a tool-crib tender for each crib, and to make this a paying proposition the department served must be of fairly large size, for example it would be questionable to provide a crib and tender for less than 25 men, as the bell system and tool messengers would be much cheaper. Occasionally, however, the crib is tended by the foreman, being in the nature of a locked cupboard to which he has the key. This is a compromise for small departments which are remote from the tool room which has worked to advantage.

**163. The necessity of a department tool crib** may be ascertained by keeping a record of the tool calls from that department and the proper tools to be carried may be found in the same manner. Observations as to the total number of daily calls will also show the saving possible by the use of messengers. An average of 5 minutes per man per call is not too great to allow for interruption of productive work while the mechanic is away from his machine.

**164. Issuing tools in sets.** Where tooling lists are available and a part of the regular system, being specified on the order or set-up

card, it is often convenient to issue all of the tools required for a given job in a set. The elaborateness of the sets involved varies from a wooden block with holes which contain tap-drills and taps for a given size thread, to a complete assortment of cutting tools, gages, and jigs. Such methods are illustrated in Fig. 49, which shows the tool list for a special job at the F. B. Stearns Co.'s shops. Such methods are of great convenience in quantity manufacture, but would be rather expensive to apply to a jobbing shop, since a standard tool list would be impossible to determine. For duplicate manufacture, however, the set for a given operation may be kept together, inspected every time it is returned, the cutting tools ground, and the gages inspected for size, and made ready for issue again.

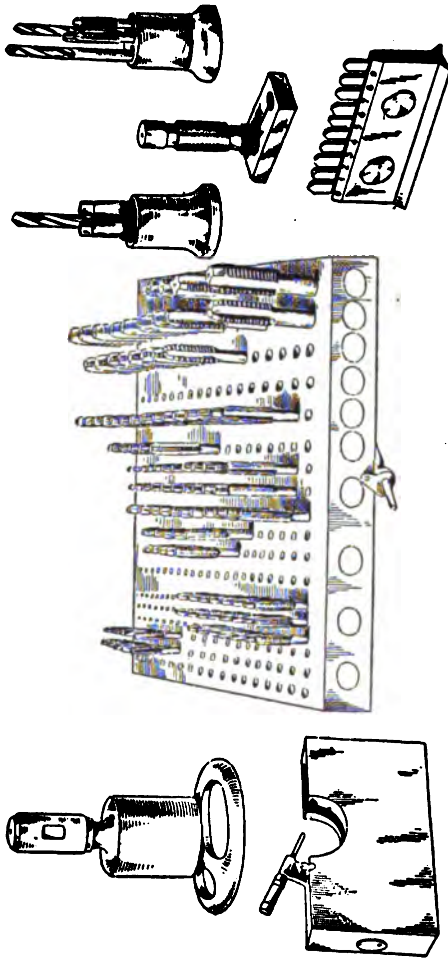


FIG. 50.—Various methods of handling small tools, gages, etc.

**165. Method of paying tool boys and messengers.** Tool boys are usually recruited from the ranks of apprentices who are just beginning to learn their trade, the first 3 to 6 months being applied in this manner to give them a familiarity with the shop and with the tools used. While this is no doubt

good for the boys it does not necessarily mean the best service for the plant, since the ranks are continually changing, and by the time a boy has got to be of value he is taken away from this job and put on a machine. A better plan for good service is to hire boys for this particular service. Sometimes they are paid on a piecework basis, so much per call or errand. This scheme has worked out to advantage as it makes them anxious to get the calls instead of to avoid them as is sometimes the case. It is quite exceptional to see a tool boy give any evidence of hurry, and when they are seen to actually run under the influence of piecework, its value is apparent. There are disadvantages, as most of the boys are on the lookout for short trips and watch the annunciator with this purpose in view, but this can be remedied by insuring that they take turns.

**166. Other work for tool boys and messengers.** In one plant it was observed that when the tool boys had any time upon their hands they would take out their jack knives and begin to carve the bench provided for them. An idle boy is generally in mischief or else planning it, and to avoid such idle periods and give them a chance to make extra money they were provided with hammer, nails and cut lumber of proper size to make standard crates. In this way idle moments were turned into industrious ones to the general satisfaction of the boys and the company.

**167. Tool checks and their use.** The most common tool check used is the embossed or engraved brass check with a number on it, usually corresponding to the employees check number. A certain number of these are issued to each man who will require tools from the tool crib. This number is quite generally 10, but for certain machines more may be allowed. The employee is responsible for these checks and must return them to get his final pay when he quits.

**168.** In *using the single-check system*, with the brass tool checks, one is presented for each tool drawn out. The tool keeper hangs the check, which is provided with a hole for that purpose, upon a hook at the location of the tool drawn, and identifying it. Under this scheme, it is possible to tell which employees have certain tools, but it is hard to tell what tools each employee has out unless a complete search of all checks on the hooks is made.

**169.** To enable the information to be had, the "*double-check" tool system* is used. Under this system, two checks are presented at the tool crib window instead of one for each article drawn. The checks are usually of cardboard instead of metal. One of them is hung on the tool hook in the usual way, the other which contains a note of the tool drawn is filed against the man's number. In this way a glance will be sufficient to tell just what tools each man has in use, and matters are much facilitated in straightening up checks when an employee quits.

The B. F. Stearns Co. employs a double-check tool system somewhat along these lines, described by Paul Campbell in the American Machinist, vol. 40, p. 887. The rules for securing tools given below are reprinted from that article, also the description of the way in which this system operates and the cost of maintaining it.

"This cabinet contains 10 drawers, each divided in the center,

each half in turn being divided into 10 triangular-shaped slots or pockets. These pockets constitute an individual till, and are labeled with the workman's clock number. This system has the distinct advantage of showing the exact state of the account of any man with the tool crib, and, the checks being made out in the handwriting of the man using the tools, all argument as to whether a man has a given tool is eliminated.

## NOTICE

### How to Secure Tools

1st Read Your Time Card, Tool List or Blue-print. Then You Will Know—

2nd What to Ask for, for Your Job.

3rd Write Tool Check with Your Number and Tool Desired on Both Halves of the Check.

4th Remember You Are Responsible for the Tools on Your Checks. Do Not Lend Your Tools, But Return Them at Once When through Using.

5th This Is a Place for Business. Patience and Courtesy Are Required and Will Be Exacted on Both Side of This Window. Violation of This Rule Will Not Be Tolerated.

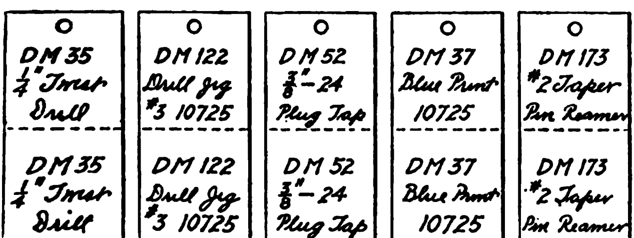



Fig. 51.—Double tool checks and working instructions.

"Upon the return of the tool drawn out, both halves of the check e returned to the workman, who is required to destroy them. It ıs at first thought that some men might seek to secure tools by rging the writing of another man. No trouble from this source s been experienced, as the tool crib tenders are familiar with the

numbers of all the men, and their first action is to compare the number of the check with the man presenting it.

"In the 18 months of use of this check system, the cost for a shop of 600 men has averaged $3.80 per month, the checks being furnished at a cost of $1.38 per 1000."

See Figs. 51, 52 and 53.

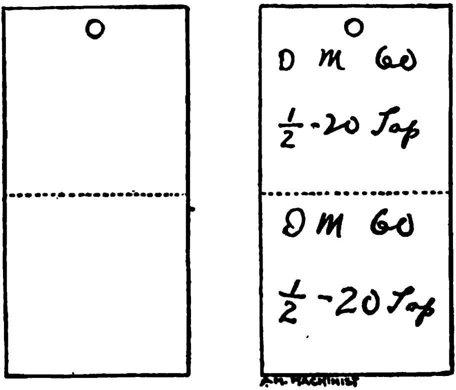



FIG. 52.—Blank and filled double tool checks.

**170. The double-check tool-room system** employed by the Westinghouse Electric and Manufacturing Co. is thus described by L. P. Alford in the American Machinist, vol. 30, p. 325. *The key* of their method lies in the fact that every tool, or group of associated tools, has an individual brass check, corresponding in size and shape with the workman's check. The illustration, Fig. 53, shows a workman's check for No. 7321, and a tool check for a $1\frac{1}{16}$-inch snap gage. All tools of a general character, as drills, reamers, arbors, gages, etc., are provided with a check similar to the one shown, which bears a legend, stating the size and kind of the tool. Special jigs, fixtures and the like, are numbered in consecutive order, and the corresponding tool checks bear this number. A careful catalog record is kept of all these tools. Associated groups of tools, as perhaps a milling fixture, its set blocks, cutters, and so on, are put in a box and given a list number which applies to the lot. Thus there is an individual brass check for each tool, or group of tools, as the case may be. In use the workman presents one of his own checks when taking a tool from the tool room.

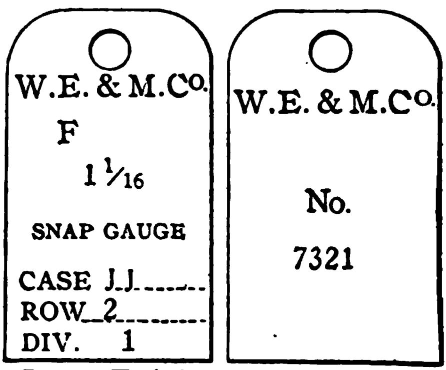



FIG. 53.—Westinghouse double check system.

This check is placed on the board, cabinet, or drawer from which the tool has been removed. The tool check corresponding with the tool which has been taken, and which has been hanging on a hook in front of the box, drawer or compartment, is hung on a workman's check board on a hook numbered to correspond with the workman's number. When double checks are used sometimes one set is round and the other square for convenience in distinguishing them.

**171. Tools not issued on checks.** It is customary for the company to provide certain tools such as oil cans, chisels, handles, scrapers and brushes to each employee requiring them for his work. These are usually given out when the man begins work at the time that he receives his tool crib checks. To insure that they are returned before quitting, it is customary in most plants to have a form

| NAME SMITH, JOHN | | | DEPT YATES | CLOCK NO 310 | |
|---|---|---|---|---|---|
| I HAVE, THIS DATE RECEIVED THE FOLLOWING TOOLS CHECKED AND AGREE TO RETURN SAME WHEN LEAVING THE EMPLOY OF THE MINNEAPOLIS STEEL & MACHINERY COMPANY | | | | | |
| 1 | OIL CAN | | AIR DRILL | | LATHE OR PLANER TOOLS |
| 3 | WRENCHES | | AIR HAMMER | | |
| 2 | CHISELS | 1 | BENCH BRUSH | | |
| 2 | CHUCKS | 1 | FILE CARD | | |
| 1 | VIXEN FILES | | "C" CLAMPS | | |
| 2 | FILES | | STILLSON WRENCH | | |
| 10 BRASS CHECKS WHICH I WILL RETURN OR PAY 50c FOR EACH ONE LOST | | | | | |
| DATE JUL 1 1913 | | SIGNATURE John Smith | | | |

FIG. 54.—Record of tools, etc., not issued on checks.

on which these items are recorded. This is kept on file in the tool room. The pay clerk is instructed that final pay is not to be made until this slip is returned signed by the tool-room foreman or tool keeper stating that the articles have been returned.

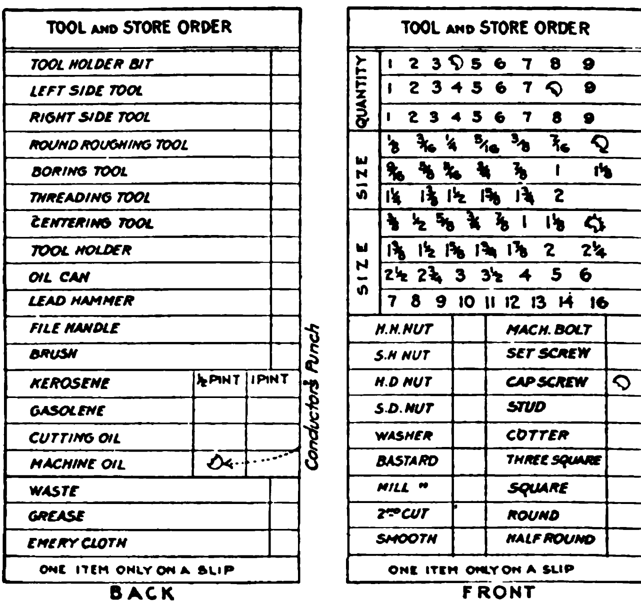
**172. Keeping track of files and lathe tools.** Files form such a large item of expense that it is good practice to require an order signed by the foreman before one is exchanged or a new one issued. The number and kinds of files issued to a new employee should be recorded on the tool charge slip mentioned in (171). Some firms have a standard assortment of files which are given to each bench or machine hand requiring them, and which are kept in portable wooden racks on top of the benches to be accessible for inspection. The chief objection to this seems to be the habit of "borrowing without asking," whereby an unscrupulous employee would replenish his stock at the expense of another. A better plan would be to make the portable file case of such size as to admit it into the drawer or cupboard, or to provide it with a lock cover operated by the same key as the drawer.

**173. List of "tools not issued on checks."** The nature of the tools which are provided mechanics varies according to the class

of work that they do, also according to the policy of the concern. For example, some shops provide monkey wrenches, others consider them as a part of the workman's kit. The following may be taken as a fairly representative list for machine hands and assemblers:

| *Machine hands* | *Assemblers* |
|---|---|
| Hammer | Hammer |
| Monkey wrench | Monkey wrench |
| Soft hammer | Soft hammer |
| Oil can | Oil can |
| Bench brush | Bench brush |
| Chisels—flat | Chisels—flat |
| center | cape |
| File handles | round |
| *Files*, varying with the policy of the shop and nature of work | oil gaining |
| | Flat and half round scrapers |
| | File handles |
| | *Files*, varying with nature of work |
| | Hack-saw frame |
| | Screw drivers |
| Center punch. | Center punch. |

**174. Lathe and other cutting tools,** especially of high-speed steel, amount to more than would be thought. Several tons of this ma-



TOOL AND STORE ORDER (BACK)

| TOOL AND STORE ORDER | | |
|---|---|---|
| TOOL HOLDER BIT | | |
| LEFT SIDE TOOL | | |
| RIGHT SIDE TOOL | | |
| ROUND ROUGHING TOOL | | |
| BORING TOOL | | |
| THREADING TOOL | | |
| CENTERING TOOL | | |
| TOOL HOLDER | | |
| OIL CAN | | |
| LEAD HAMMER | | |
| FILE HANDLE | | |
| BRUSH | | |
| KEROSENE | ½ PINT | 1 PINT |
| GASOLENE | | |
| CUTTING OIL | | |
| MACHINE OIL | | |
| WASTE | | |
| GREASE | | |
| EMERY CLOTH | | |
| ONE ITEM ONLY ON A SLIP | | |

Conductor's Punch

TOOL AND STORE ORDER (FRONT)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| QUANTITY | 1 | 2 | 3 | | 5 | 6 | 7 | 8 | 9 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | 9 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| SIZE | 1/8 | 3/16 | 1/4 | 5/16 | 3/8 | 7/16 | | | |
| | 9/16 | 5/8 | 11/16 | 3/4 | 7/8 | 1 | 1 1/8 | | |
| | 1 1/4 | 1 3/8 | 1 1/2 | 1 5/8 | 1 3/4 | 2 | | | |
| SIZE | 3/8 | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | | |
| | 1 3/8 | 1 1/2 | 1 5/8 | 1 3/4 | 1 7/8 | 2 | 2 1/4 | | |
| | 2 1/2 | 2 3/4 | 3 | 3 1/2 | 4 | 5 | 6 | | |
| | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 16 |

| | | | |
|---|---|---|---|
| H.H. NUT | | MACH. BOLT | |
| S.H NUT | | SET SCREW | |
| H.D NUT | | CAP SCREW | |
| S.D. NUT | | STUD | |
| WASHER | | COTTER | |
| BASTARD | | THREE SQUARE | |
| MILL " | | SQUARE | |
| 2ND CUT | | ROUND | |
| SMOOTH | | HALF ROUND | |
| ONE ITEM ONLY ON A SLIP | | | |

BACK FRONT

FIG. 55.—Store order showing use of conductor's punch.

...al are lying around under benches and in machine cabinets in ...erage shop. It is good practice to issue these tools on the tool

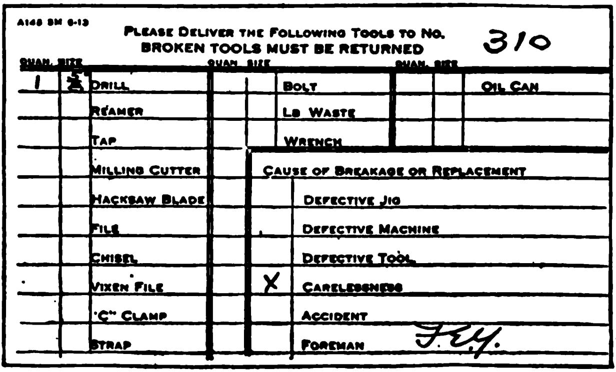
| DRG. NO. | OPERATION | LOCATION | | NAME OF PIECE |
|---|---|---|---|---|
| | | SECTION | SHELF | |
| TA 1015A | No. 1 | J | 1 | DRILL JIG<br>LOWER GASOLENE RIM ECC. STRAP |

| SPECIAL TOOLS | | STANDARD TOOLS | |
|---|---|---|---|
| 1 | STRAP AND HANDWHEEL | 1 | 23/64" DRILL |
| 1 | PLATE WITH 2 BUSHINGS | 1 | 31/64" " |
| | | 1 | 13/64" " |
| | | 1 | 3/8" MACH. REAMER |
| | | 1 | 1/2" " " |
| | | 1 | 3/8" STD. PLUG GAUGE |
| | | 1 | 1/2" " " " |
| | | 1 | No 1 TO 2 SLEEVE |
| | | | |
| | | | |
| | | | |
| | | | |

Fig. 56.—Report of tools comprising a set.


Fig. 57.—A rack for gear-cutters.

charge slip and require a foreman's order for a new one, as with files. It is also good policy to call in all cutting tools from the shop at frequent periods. This does not apply when the plant is using a central tool grinding department and has standardized tools, in


A148 5M 6-13

PLEASE DELIVER THE FOLLOWING TOOLS TO NO. 310
BROKEN TOOLS MUST BE RETURNED

| QUAN. | SIZE | | QUAN. | SIZE | | QUAN. | SIZE | |
|---|---|---|---|---|---|---|---|---|
| 1 | ¾ | DRILL | | | BOLT | | | OIL CAN |
| | | REAMER | | | LB WASTE | | | |
| | | TAP | | | WRENCH | | | |
| | | MILLING CUTTER | | | CAUSE OF BREAKAGE OR REPLACEMENT | | | |
| | | HACKSAW BLADE | | | DEFECTIVE JIG | | | |
| | | FILE | | | DEFECTIVE MACHINE | | | |
| | | CHISEL | | | DEFECTIVE TOOL | | | |
| | | VIXEN FILE | X | | CARELESSNESS | | | |
| | | "C" CLAMP | | | ACCIDENT | | | |
| | | STRAP | | | FOREMAN F. E. Y. | | | |

FIG. 58.—Report of broken tools.

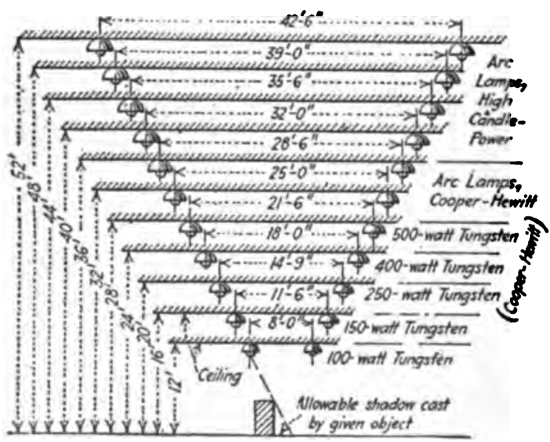



FIG. 59.—Types of lamps suited to various ceiling heights.

which case they are issued on tool checks the same as drills or reamers.

In a large department, the foreman is called upon at frequent intervals to stop and sign orders for tools and materials. Often he has to write quite a few words to describe what is wanted as well as to sign his name or initials. This labor on his part is practically

eliminated if he is provided with a printed form, shown in Fig. 55, and a conductor's punch. Items of ordinary use are specified on this form and the punch mark replaces the signature as well as indicating what is wanted.

**175. Shop illumination with various heights of ceiling.** The following illustration from the American Machinist illustrates the various types of lamps which are adapted for illuminating shops of various ceiling heights. The maintenance of the efficiency of any shop-lighting system depends to a large extent upon the amount of care given to the cleanliness of reflectors and globes, and so on. Tests have repeatedly shown that lamps and reflectors but ordinarily dirty lose as much as 50 per cent. of illuminating efficiency, in other words increasing the lighting bill 50 per cent. per unit of light delivered. See Fig. 59.

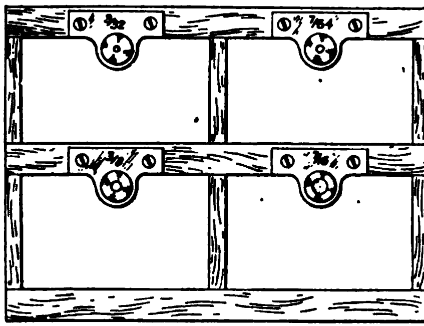


FIG. 60.—Gaging device for drills at the bins.

**176. Preventing mistakes in drill sizes.** The Cleveland Automatic Machine Co., Cleveland, Ohio, has a good system in the tool room to prevent mistakes in putting away and giving out drills to any of the men.

As can be seen from Fig. 60, this consists of the usual tool-room storage bin for small drills. Each number plate, however, carries a hardened steel bushing of the proper diameter in addition to having the size stamped on it.

## STANDARDIZATION OF MACHINES AND TOOLS

**177. Standardization of machine speeds and feeds, machine parts and cutting tools.** Carl G. Barth is the foremost exponent of standardization of machine speeds and feeds. On the following pages we present some interesting examples in the respeeding of machine tools made under his supervision and also logarithmic diagrams which show the ideal series and how closely it has been approached.

Standardized lathe tools have been fully covered by Frederick G. Taylor in his "Art of Cutting Metals," and data are also obtainable on this subject from the Wm. Sellers Co., and the Tabor Manufacturing Co., of Philadelphia. A number of standardized "special" tools, used in the government shops at the Watertown Arsenal and covering a wide field, are presented. The tools shown represent the work of Mr. Barth in this field. (See Figs. 61 to 92.)

| MACHINE NO. | [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|---|
| 1 LE | 72" | 28' | 52" | 18.7' |
| 2 LE | 68" | 35.5' | 41" | 23' |
| 3 LE | 46½" | 22.3' | 37" | 17' |
| 4 LE & 5 LE | 45" | 24' | 34" | 16' |
| 6 LE | 39" | 29' | 31" | 23' |
| 7 LE | 36" | 70' | 25½" | 50' |
| 8 LE | 34" | 66' | 21½" | 42' |
| 9 & 10 LE | 33" | 39' | 22" | 26' |
| 11 & 12 LE | 31" | 44' | 19¾" | 28' |
| 13 LE | 30½" | 44' | 19" | 27.5' |
| 14 & 15 LE | 30½" | 28' | 22" | 20.5' |
| 17 LE | 27½" | 41' | 17" | 25.5' |
| 18 LE | 26" | 48' | 18" | 35' |
| 19 LE | 25¼" | 50' | 14¾" | 29' |
| 20-21 & 22 LE | 25" | 49' | 16" | 31.3' |
| 24 LE | 24½" | 48' | 14½" | 28.5' |
| 25 LE | 21½" | 56' | 13" | 34' |
| 26 LE | 21" | 46' | 11" | 25' |
| 27 & 28 LE | 21" | 46.5' | 14¼" | 31.5' |
| 29 LE | 22" | 38.5' | 12" | 21' |
| 30 LE | 20¾" | 48' | 12" | 28' |
| 31-32 & 33 LE | 19¼" | 45' | 12" | 28' |

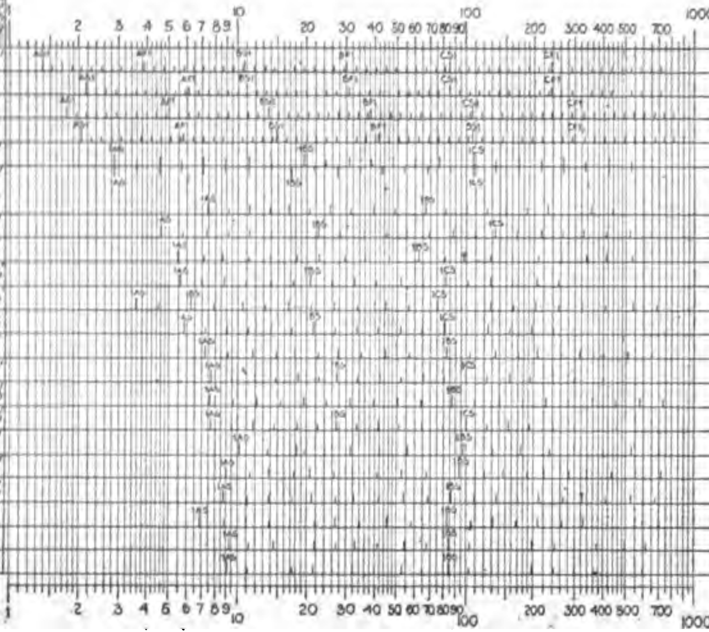
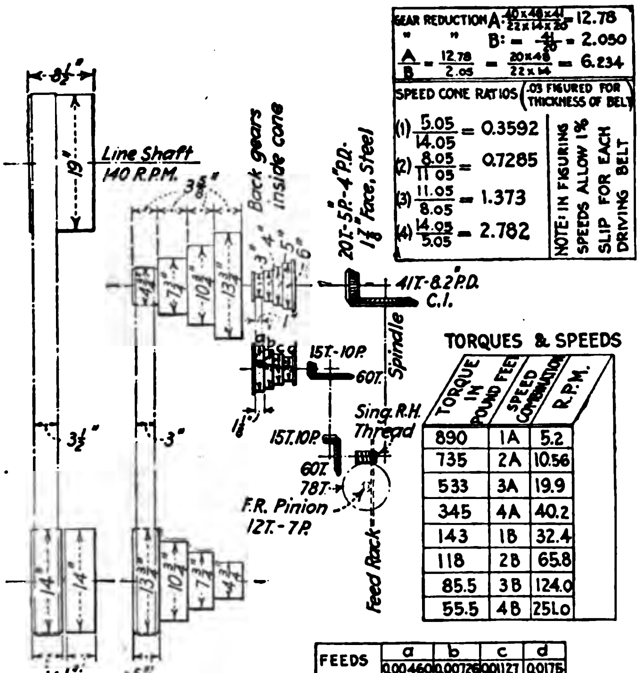



**Fig. 61.—Logarithmic diagram of respeeded lathes.**
Showing the revolutions per minute obtained by successive speed changes on lathes with pulley steps and gear ratios modified.




AM. MACHINIST

FIG. 62.—Original arrangement of a 30-in. vertical drilling machine.

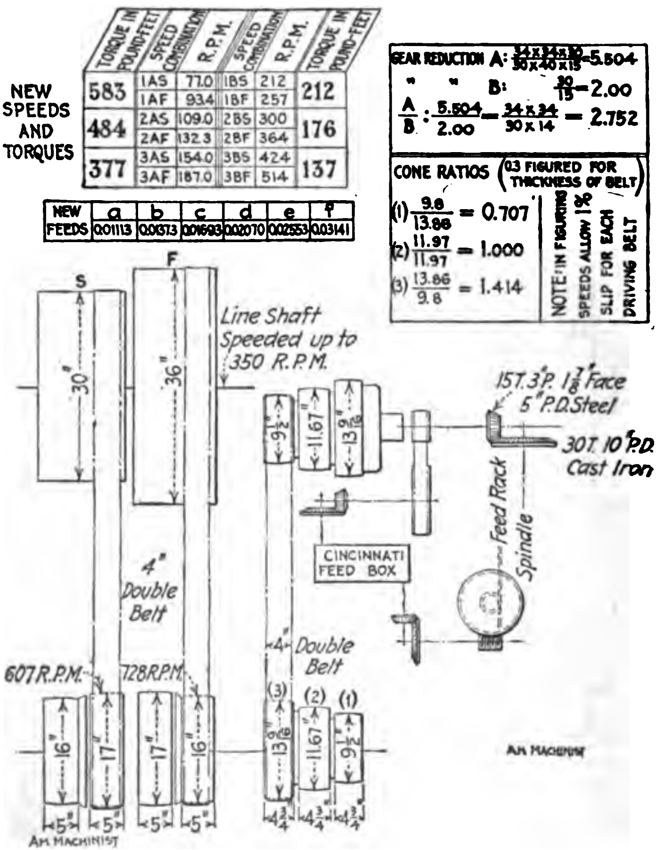
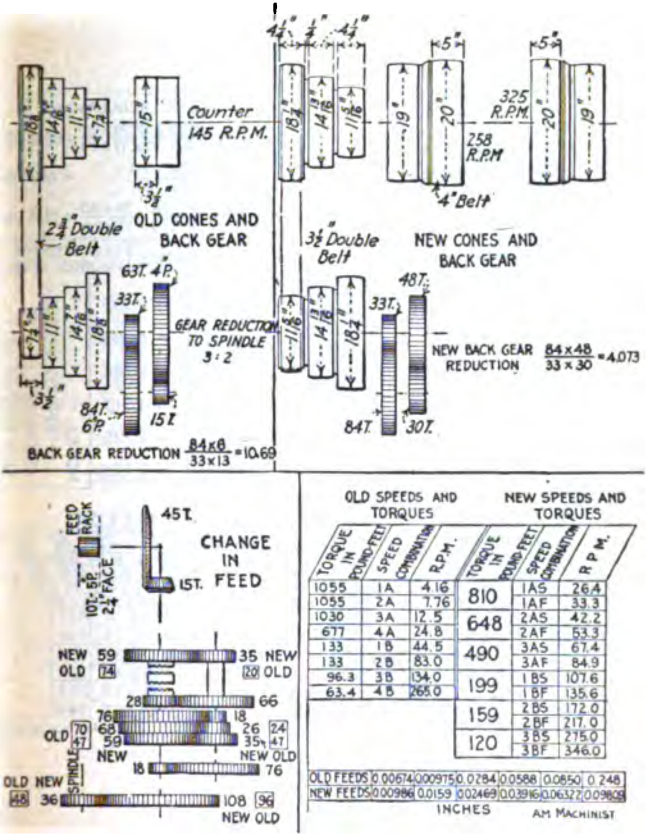



FIG. 63.—Modified speeds and torques on the drilling machine shown in FIG. 62.




| Torque in pound-feet (old) | Speed combination (old) | R.P.M. (old) | Torque in pound-feet (new) | Speed combination (new) | R.P.M. (new) |
|---|---|---|---|---|---|
| 1055 | 1A | 4.16 | 810 | 1AS | 26.4 |
| 1055 | 2A | 7.76 | | 1AF | 33.3 |
| 1030 | 3A | 12.5 | 648 | 2AS | 42.2 |
| 677 | 4A | 24.8 | | 2AF | 53.3 |
| 133 | 1B | 44.5 | 490 | 3AS | 67.4 |
| 133 | 2B | 83.0 | | 3AF | 84.9 |
| 96.3 | 3B | 134.0 | 199 | 1BS | 107.6 |
| 63.4 | 4B | 265.0 | | 1BF | 135.6 |
| | | | 159 | 2BS | 172.0 |
| | | | | 2BF | 217.0 |
| | | | 120 | 3BS | 275.0 |
| | | | | 3BF | 346.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| OLD FEEDS | 0.00674 | 0.00975 | 0.0284 | 0.0588 | 0.0850 | 0.248 |
| NEW FEEDS | 0.00986 | 0.0159 | 0.02469 | 0.03916 | 0.06327 | 0.09809 |

**Fig. 64.—Original and changed speeds on a radial drilling machine.**

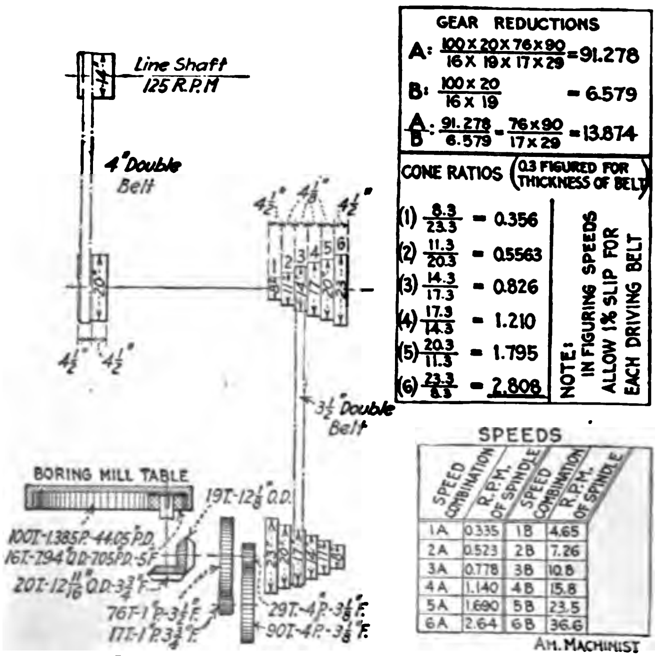
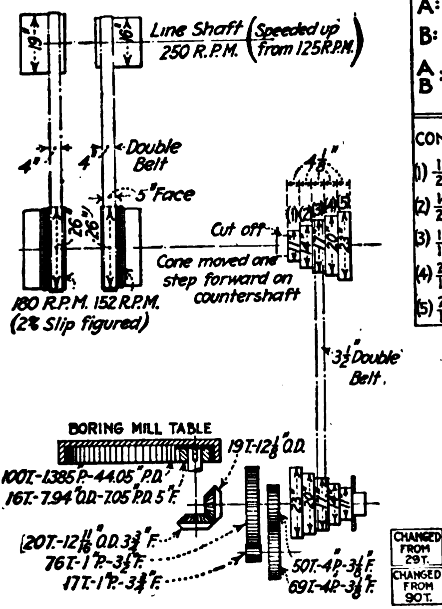



FIG. 65.—Original speeding of a 5-ft. boring mill.




**GEAR REDUCTIONS**

$$A: \frac{100 \times 20 \times 76 \times 69}{16 \times 19 \times 17 \times 50} = 40.588$$

$$B: \frac{100 \times 20}{16 \times 19} = 6.579$$

$$\frac{A}{B}: \frac{40.588}{6.579} = \frac{76 \times 69}{17 \times 50} = 6.1694$$

**CONE RATIOS** (0.3 FIGURED FOR THICKNESS OF BELT)

(1) $\frac{11.3}{23.3} = 0.485$

(2) $\frac{14.3}{20.3} = 0.704$

(3) $\frac{17.3}{17.3} = 1.000$

(4) $\frac{20.3}{14.3} = 1.420$

(5) $\frac{23.3}{11.3} = 2.062$

NOTE: IN FIGURING SPEEDS ALLOW 1% SLIP FOR EACH DRIVING BELT

| SPEED COMBINATION | R.P.M. OF SPINDLE | SPEED COMBINATION | R.P.M. OF SPINDLE |
|---|---|---|---|
| 1AS | 1.816 | 1BS | 11.2 |
| 1AF | 2.152 | 1BF | 13.3 |
| 2AS | 2.635 | 2BS | 16.25 |
| 2AF | 3.12 | 2BF | 19.3 |
| 3AS | 3.74 | 3BS | 23.1 |
| 3AF | 4.43 | 3BF | 27.4 |
| 4AS | 5.32 | 4BS | 32.8 |
| 4AF | 6.29 | 4BF | 38.9 |
| 5AS | 7.71 | 5BS | 47.6 |
| 5AF | 9.14 | 5BF | 56.4 |

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FIG. 66.—Respeeded 5-ft. mill.

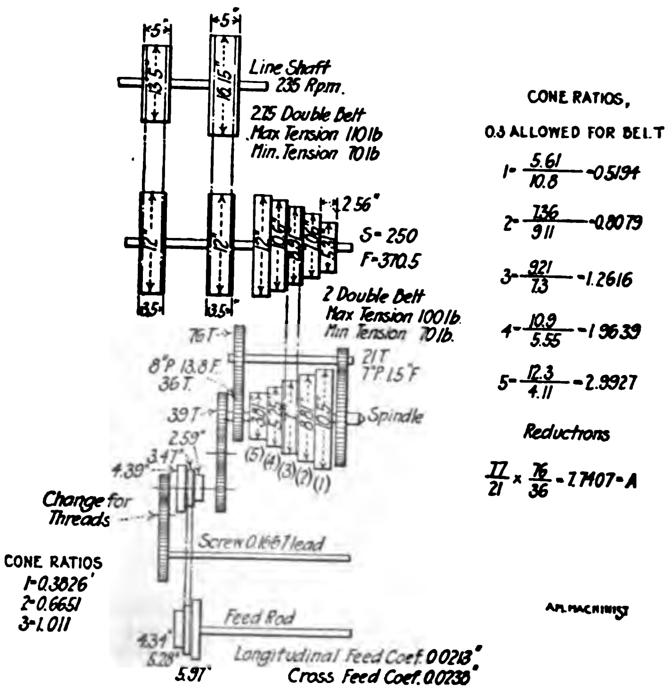



FIG. 67.—Respeeded 16-in. lathe.

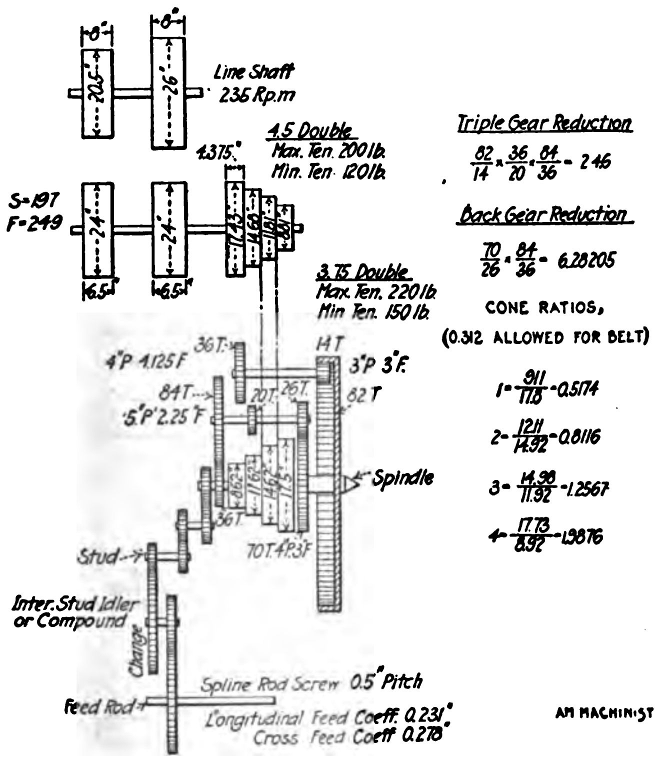
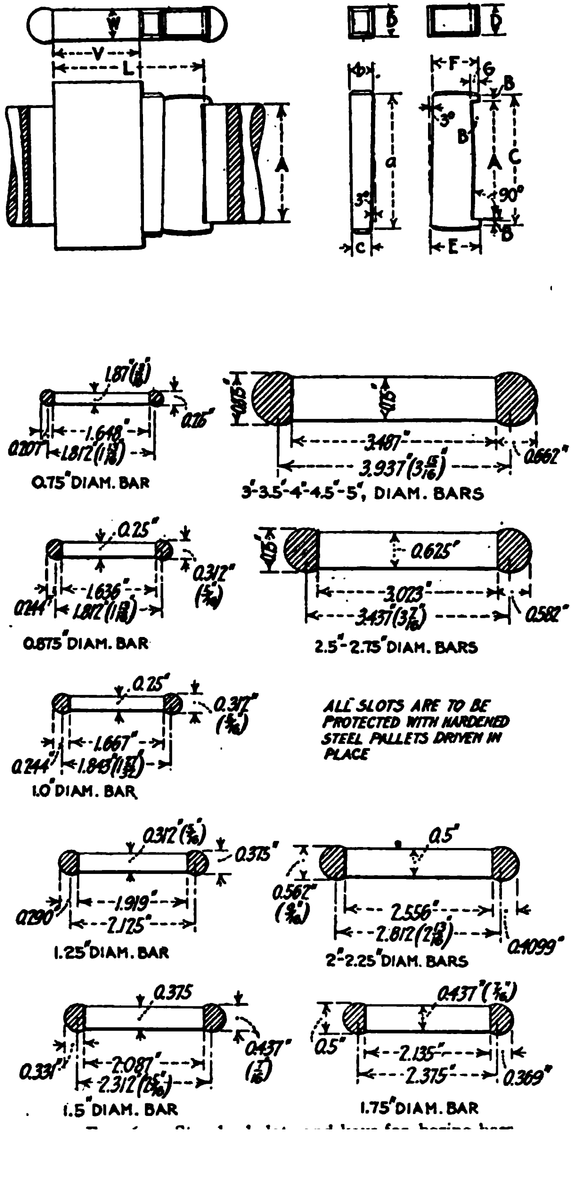



FIG. 68.—Respeeded 32-in. lathe.


0.75" DIAM. BAR
3"-3.5"-4"-4.5"-5", DIAM. BARS
0.875" DIAM. BAR
2.5"-2.75" DIAM. BARS
1.0" DIAM. BAR
ALL SLOTS ARE TO BE PROTECTED WITH HARDENED STEEL PALLETS DRIVEN IN PLACE
1.25" DIAM. BAR
2"-2.25" DIAM. BARS
1.5" DIAM. BAR
1.75" DIAM. BAR

| No. of Taper | Plug Depth "P" | Small end of Plug "D" | Large end of Plug "A" | Taper In. of Diam. per Ft. | C | E | H | S | Keyways | | L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | W | K | |
| 1 | 2 | 0.375 | 0.475 | 0.6 | 0.125 | 0.25 | 2.125 | ........ | ........ | ........ | ........ |
| 2 | 2.4375 | 0.578 | 0.7 | 0.602 | 0.1875 | 0.375 | 2.5625 | 0.5625 | 0.1875 | 0.125 | ........ |
| 3 | 3 | 0.787 | 0.938 | 0.602 | 0.25 | 0.625 | 3.1875 | 0.625 | 0.25 | 0.1875 | ........ |
| 4 | 3.875 | 1.030 | 1.231 | 0.623 | 0.3125 | 0.75 | 4.0625 | 0.75 | 0.375 | 0.3125 | ........ |
| 5 | 5 | 1.485 | 1.748 | 0.630 | 0.375 | 1 | 5.1875 | 1 | 0.5 | 0.375 | 3.25 |
| 6 | 6.875 | 2.135 | 2.494 | 0.626 | 0.375 | 1.75 | 7.25 | 1.5 | 0.625 | 0.5 | 4.5 |
| 7 | 9.5 | 2.775 | 3.27 | 0.625 | 0.5 | 2.5 | 10 | 2 | 0.75 | ........ | 6.75 |

Morse Taper Shanks.

| Diam. of Bar A. | Slot | | Cutter | | Key | | | Gib | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | W | V | W | a | b | c | D | A. | B | C | D | E | F | G |
| 0.75 | 1.648 | 0.187 | 1 | 0.185 | 0.95 | 0.241 | 0.192 | 0.172 | 0.75 | 0.06 | 0.87 | 0.172 | 0.515 | 0.469 | 0.07 |
| 0.875 | 1.636 | 0.25 | 1 | 0.248 | 1.075 | 0.240 | 0.184 | 0.235 | 0.875 | 0.06 | 0.995 | 0.235 | 0.51 | 0.458 | 0.07 |
| 1 | 1.667 | 0.25 | 1 | 0.248 | 1.2 | 0.253 | 0.190 | 0.235 | 1 | 0.06 | 1.12 | 0.235 | 0.533 | 0.474 | 0.07 |
| 1.25 | 1.919 | 0.312 | 1 | 0.310 | 1.50 | 0.345 | 0.267 | 0.296 | 1.25 | 0.08 | 1.41 | 0.296 | 0.729 | 0.655 | 0.095 |
| 1.5 | 2.087 | 0.375 | 1.25 | 0.373 | 1.75 | 0.327 | 0.235 | 0.355 | 1.5 | 0.08 | 1.66 | 0.355 | 0.682 | 0.595 | 0.095 |
| 1.75 | 2.135 | 0.437 | 1.25 | 0.435 | 2.00 | 0.347 | 0.242 | 0.417 | 1.75 | 0.08 | 1.91 | 0.417 | 0.720 | 0.620 | 0.095 |
| 2 | 2.556 | 0.5 | 1.5 | 0.497 | 2.312 | 0.417 | 0.296 | 0.480 | 2 | 0.10 | 2.2 | 0.480 | 0.862 | 0.747 | 0.12 |
| 2.25 | 2.556 | 0.5 | 1.5 | 0.497 | 2.562 | 0.439 | 0.305 | 0.480 | 2.25 | 0.10 | 2.45 | 0.480 | 0.868 | 0.740 | 0.12 |
| 2.5 | 3.023 | 0.625 | 1.75 | 0.620 | 2.812 | 0.448 | 0.301 | 0.480 | 2.5 | 0.10 | 2.70 | 0.480 | 0.920 | 0.779 | 0.12 |
| 2.75 | 3.023 | 0.625 | 1.75 | 0.620 | 3.062 | 0.455 | 0.295 | 0.480 | 2.75 | 0.10 | 2.95 | 0.480 | 0.927 | 0.773 | 0.12 |
| 3 | 3.487 | 0.75 | 2 | 0.745 | 3.375 | 0.512 | 0.336 | 0.600 | 3 | 0.12 | 3.24 | 0.600 | 1.053 | 0.883 | 0.145 |
| 3.5 | 3.487 | 0.75 | 2 | 0.745 | 3.875 | 0.525 | 0.322 | 0.600 | 3.5 | 0.12 | 3.74 | 0.600 | 1.068 | 0.872 | 0.145 |
| 4 | 3.487 | 0.75 | 2 | 0.745 | 4.312 | 0.537 | 0.311 | 0.600 | 4 | 0.12 | 4.24 | 0.600 | 1.079 | 0.857 | 0.145 |
| 4.5 | 3.487 | 0.75 | 2 | 0.745 | 4.937 | 0.625 | 0.367 | 0.718 | 4.5 | 0.15 | 4.80 | 0.718 | 1.269 | 1.057 | 0.18 |
| 5 | 3.487 | 0.75 | 2 | 0.745 | 5.437 | 0.638 | 0.353 | 0.718 | 5 | 0.15 | 5.30 | 0.718 | 1.280 | 1.003 | 0.18 |

Boring Bars, Cutters, Keys and Gibs.

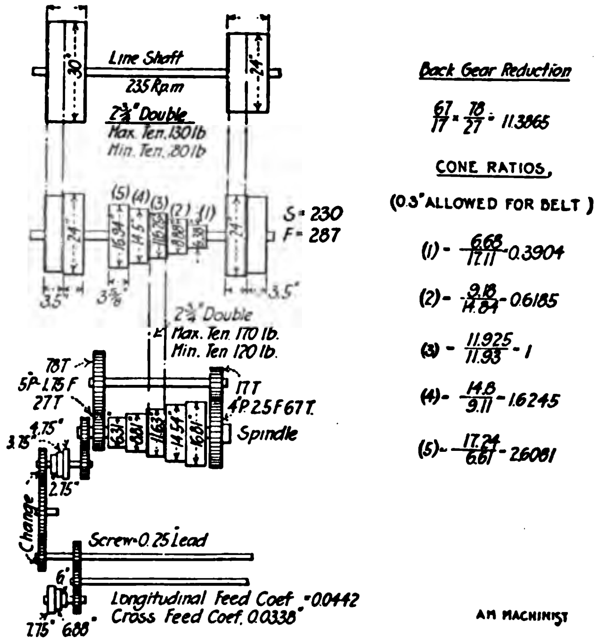
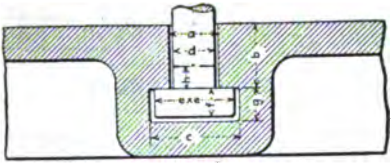



FIG. 70.—Respeeded 24-in. lathe.




DIMENSIONS FOR STANDARD T-BOLTS AND SLOTS

| DIMENSION | FORMULA FOR DIMENSION | DIAMETER OF BOLTS | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3/8 | 7/16 | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 3/8 | 1 1/2 | 1 5/8 | 1 3/4 | 1 7/8 | 2 | 2 1/4 | 2 1/2 | 2 3/4 | 3 | 3 1/2 | 4 |
| a | d + 1/16 | 7/16 | 1/2 | 9/16 | 11/16 | 13/16 | 15/16 | 1 1/16 | 1 3/16 | 1 5/16 | 1 7/16 | 1 9/16 | 1 11/16 | 1 13/16 | 1 15/16 | 2 1/16 | 2 5/16 | 2 9/16 | 2 13/16 | 3 1/16 | 3 9/16 | 4 1/16 |
| b | 1 1/2 d | 9/16 | 21/32 | 3/4 | 15/16 | 1 1/8 | 1 5/16 | 1 1/2 | 1 11/16 | 1 7/8 | 2 1/16 | 2 1/4 | 2 7/16 | 2 5/8 | 2 13/16 | 3 | 3 3/8 | 3 3/4 | 4 1/8 | 4 1/2 | 5 1/4 | 6 |
| c | 1 7/8 d + 3/16 | 7/8 | 1 | 1 1/8 | 1 11/32 | 1 19/32 | 1 13/16 | 2 1/16 | 2 9/32 | 2 17/32 | 2 3/4 | 3 | 3 7/32 | 3 15/32 | 3 11/16 | 3 15/16 | 4 13/32 | 4 7/8 | 5 1/4 | 5 13/16 | 6 3/4 | 7 3/4 |
| e | 1 3/4 d + 1/16 | 23/32 | 27/32 | 15/16 | 1 5/32 | 1 3/8 | 1 19/32 | 1 13/16 | 2 | 2 1/4 | 2 3/8 | 2 11/16 | 2 7/8 | 2 13/16 | 3 1/8 | 3 5/16 | 4 1/8 | 4 3/8 | 4 7/8 | 5 5/16 | 6 1/4 | 7 1/16 |
| f | 5/8 d + 1/16 | 9/32 | 11/32 | 3/8 | 15/32 | 17/32 | 19/32 | 11/16 | 3/4 | 13/16 | 7/8 | 1 | 1 1/32 | 1 1/8 | 1 7/32 | 1 5/16 | 1 15/32 | 1 5/8 | 1 25/32 | 1 15/16 | 2 1/4 | 2 9/16 |
| g | 11/16 d + 1/8 | 3/8 | 13/32 | 15/32 | 17/32 | 5/8 | 23/32 | 13/16 | 29/32 | 1 | 1 3/32 | 1 3/16 | 1 9/32 | 1 11/32 | 1 13/32 | 1 1/2 | 1 21/32 | 1 27/32 | 1 7/8 | 2 1/16 | 2 1/2 | 2 7/8 |
| h | 7/16 d + 1/16 | 7/32 | 1/4 | 9/32 | 11/32 | 3/8 | 7/16 | 1/2 | 9/16 | 5/8 | 21/32 | 23/32 | 3/4 | 13/16 | 7/8 | 13/16 | 1 1/16 | 1 3/32 | 1 1/4 | 1 3/8 | 1 19/32 | 1 13/16 |

←····SIZE OF SLOTS····→

FIG. 71.—Barth's standard T-slots.

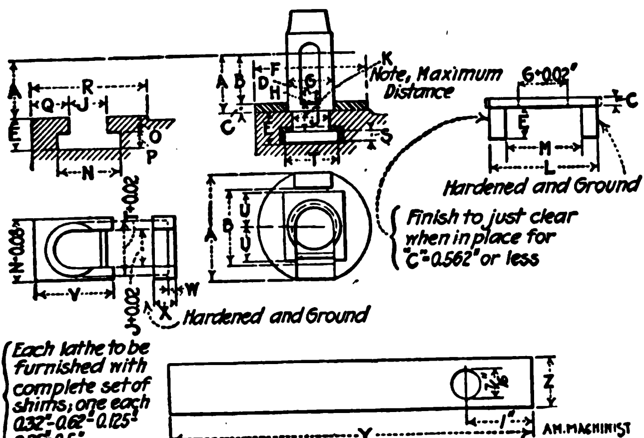



FIG. 72.—Standard tool posts and shims for lathes.
(See pages 118–119)

| Lathe No. | R. No. | St'd. Size Tool | A | B | C | D | E | F | G | H | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 250 | 23LE | 0.75 | 2.343 | 2 | 0.343 | 0.937 | 1.562 | 6 | 2.375 | 0.093 | 1.5 | 1.375 | 5.75 | 4.25 | 2.468 |
| 158 | 25LE | 0.75 | 2.406 | 2 | 0.406 | 0.875 | 1.062 | 4.875 | 2 | | 1.312 | 1 | 4.625 | 3.25 | 2.062 |
| | 27LE | 0.75 | 2.5 | 2 | 0.5 | 1 | 1.375 | 5.25 | 2.25 | | 1.875 | 1.406 | 5 | 3.5 | 2.875 |
| | 28LE | 0.75 | 2.5 | 2 | 0.5 | 1 | 1.375 | 5.25 | 2.25 | | 1.875 | 1.406 | 5 | 3.5 | 2.875 |
| 259 | 31LE | 0.625 | 2.312 | 1.687 | 0.625 | 0.937 | 1 | 4 | 1.75 | | 1.75 | 1.062 | 3.75 | 2.5 | 2.5 |
| 263 | 32LE | 0.625 | 2.25 | 1.687 | 0.562 | 0.875 | 1 | 4 | 1.75 | | 1.75 | 0.937 | 3.75 | 2.5 | 2.437 |
| 271 | 33LE | 0.625 | 2.343 | 1.687 | 0.656 | 1 | 1 | 4 | 1.687 | | 1.75 | 1 | 3.5 | 2.625 | 2.5 |
| 215 | 34LE | 0.625 | 2.25 | 1.687 | 0.562 | 0.812 | 1.187 | 4.5 | 1.75 | | 1.187 | 1.25 | 4 | 2.75 | 2 |
| 214 | 39LE | 0.625 | 2.25 | 1.687 | 0.562 | 0.812 | 1.062 | 4.5 | 1.75 | | 1.187 | 1.156 | 4 | 2.75 | 2 |
| 252 | 44LE | 0.625 | 1.687 | 1.562 | 0.125 | 0.75 | 1.187 | 3.375 | 1.625 | | 1.125 | 0.812 | 3.187 | 2.125 | 1.812 |
| 255 | 45LE | 0.625 | 1.812 | 1.562 | 0.25 | 0.812 | 1 | 3.875 | 1.687 | | 1.125 | 0.875 | 3.625 | 2.5 | 1.937 |
| 260 | 46LE | 0.625 | 1.812 | 1.562 | 0.25 | 0.812 | 1 | 3.375 | 1.687 | | 1.125 | 0.875 | 3.187 | 2.125 | 1.937 |
| 264 | 47LE | 0.625 | 1.875 | 1.562 | 0.312 | 0.75 | 1 | 3.437 | 1.75 | | 1.187 | 0.937 | 3.25 | 2.25 | 1.937 |
| 270 | 48LE | 0.625 | 1.812 | 1.562 | 0.25 | 0.75 | 1 | 3.375 | 1.75 | | 1.125 | 0.875 | 3.187 | 2.125 | 1.968 |
| 256 | 49LE | 0.625 | 1.687 | 1.562 | 0.125 | 0.75 | 1.187 | 3.5 | 1.625 | | 1.125 | 0.812 | 3.25 | 2.25 | 1.75 |
| 222 | 50LE | 0.625 | 1.75 | 1.562 | 0.187 | 0.687 | 0.625 | 2.5 | 1.437 | | 1 | 0.5 | 2.312 | 1.75 | 1.625 |
| 221 | 51LE | 0.625 | 1.781 | 1.562 | 0.218 | 0.687 | 1 | 3.75 | 1.5 | | 1.5 | 0.812 | 3.5 | 2.25 | 2.062 |
| 216 | 52LE | 0.625 | 1.812 | 1.562 | 0.25 | 0.75 | 0.937 | 4.062 | 1.656 | | 1.062 | | 3.875 | 2.75 | 1.812 |
| 210 | 53LE | 0.625 | 1.75 | 1.562 | 0.187 | 0.75 | 0.875 | 3.375 | 1.375 | | 0.875 | 0.687 | 3.25 | 2.25 | 1.5 |
| 323 | 54LE | 0.625 | 1.843 | 1.562 | 0.281 | 0.75 | 0.875 | 3.5 | 1.5 | 0.062 | 1 | | 3.312 | | 1.75 |
| 325 | 55LE | 0.625 | 1.812 | 1.562 | 0.25 | 0.75 | 0.875 | 3.5 | 1.5 | 0.062 | 1 | | 3.125 | | 1.75 |
| 333 | 56LE | 0.625 | 1.812 | 1.562 | 0.25 | 0.75 | 0.875 | 3.5 | 1.5 | 0.062 | 1 | | 3.125 | | 1.781 |
| 339 | 57LE | 0.625 | 1.812 | 1.562 | 0.25 | 0.75 | 0.875 | 3.5 | 1.5 | 0.062 | 1 | | 3.125 | | 1.75 |
| 272 | 58LE | 0.5 | 1.562 | 1.312 | 0.25 | 0.687 | 0.812 | 3.25 | 1.687 | | 1 | 0.625 | 3.125 | 2.125 | 1.812 |
| 276 | 59LE | 0.5 | 1.5 | 1.312 | 0.187 | | | | | | | | | | |

Dimensions of standard tool posts and shims.

| Lathe | | St'd. Size | O | P | Q | R | S | T | U | Tool Post Block | | X | Shims | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S. No. | R. No. | Tool | | | | | | | | V | W | | Y | Z |
| 250 | 23LE | 0.75 | 0.875 | 0.687 | 2.25 | 6 | 0.437 | 2.125 | 2 | 4 | 0.25 | 0.625 | 6.5 | 0.75 |
| 158 | 25LE | 0.75 | 0.5 | 0.562 | 1.75 | 4.75 | 0.343 | 1.812 | 1.5 | 3 | 0.187 | 0.531 | 5.5 | 0.75 |
| | 27LE | 0.75 | 0.782 | 0.593 | 1.687 | 4.187 | 0.375 | 2.5 | 1.625 | 3.25 | 0.187 | 0.562 | 5.5 | 0.75 |
| | 28LE | 0.75 | 0.782 | 0.593 | 1.687 | 4.187 | 0.375 | 2.5 | 1.625 | 3.25 | 0.187 | 0.562 | 5.5 | 0.75 |
| 259 | 31LE | 0.625 | 0.5 | 0.5 | 1.125 | 4 | | | | | | | 5 | 0.625 |
| 263 | 32LE | 0.625 | 0.437 | 0.562 | 1.125 | 4 | | | | | | | 5 | 0.625 |
| 271 | 33LE | 0.625 | 0.437 | 0.562 | 1.125 | 4 | | | | | | | 5 | 0.625 |
| 215 | 34LE | 0.625 | 0.531 | 0.656 | 1.687 | 4.625 | 0.437 | 1.687 | 1.25 | 2.5 | 0.187 | 0.625 | 5.5 | 0.625 |
| 214 | 39LE | 0.625 | 0.5 | 0.562 | 1.687 | 4.625 | 0.375 | 1.687 | 1.25 | 2.5 | 0.156 | 0.531 | 5.5 | 0.625 |
| 252 | 44LE | 0.625 | 0.562 | 0.625 | 1.125 | 3.5 | 0.375 | 1.562 | 1 | 2 | 0.187 | 0.562 | 5 | 0.625 |
| 255 | 45LE | 0.625 | 0.562 | 0.437 | 1.375 | 4 | 0.281 | 1.562 | 1.187 | 2.375 | 0.125 | 0.406 | 5 | 0.625 |
| 260 | 46LE | 0.625 | 0.562 | 0.437 | 1.125 | 3.5 | 0.281 | 1.562 | 1.031 | 2.062 | 0.125 | 0.406 | 5 | 0.625 |
| 264 | 47LE | 0.625 | 0.562 | 0.437 | 1.125 | 4 | 0.281 | 1.687 | 1.062 | 1.125 | 0.125 | 0.406 | 5 | 0.625 |
| 270 | 48LE | 0.625 | 0.562 | 0.437 | 1.125 | 3.375 | 0.281 | 1.687 | 1.031 | 2.062 | 0.125 | 0.406 | 5 | 0.625 |
| 256 | 49LE | 0.625 | 0.562 | 0.625 | 1.187 | 3.5 | 0.375 | 1.5 | 1.062 | 2.125 | 0.187 | 0.562 | 5 | 0.625 |
| 222 | 50LE | 0.625 | 0.25 | 0.375 | 0.75 | 3 | 0.25 | 1.375 | 0.843 | 1.687 | 0.125 | 0.372 | 4 | 0.625 |
| 221 | 51LE | 0.625 | 0.5 | 0.5 | 1.125 | 3.75 | | | | | | | 4 | 0.625 |
| 216 | 52LE | 0.625 | 0.229 | 0.718 | 1.5 | 4 | | | | | | | 5 | 0.625 |
| 210 | 53LE | 0.625 | 0.437 | 0.437 | 1.25 | 3.25 | 0.281 | 1.343 | 1.062 | 2.125 | 0.125 | 0.406 | 4 | 0.625 |
| 323 | 54LE | 0.625 | 0.375 | 0.5 | 1.25 | 3.5 | | | | | | | 4 | 0.625 |
| 325 | 55LE | 0.625 | 0.375 | 0.5 | 1.25 | 3.5 | | | | | | | 4 | 0.625 |
| 333 | 56LE | 0.625 | 0.375 | 0.5 | 1.25 | 3.5 | | | | | | | 4 | 0.625 |
| 339 | 57LE | 0.625 | 0.375 | 0.5 | 1.25 | 3.625 | | | | | | | 4 | 0.625 |
| 272 | 58LE | 0.5 | 0.375 | 0.437 | 1.125 | 3.375 | 0.281 | 1.562 | 1 | 2 | 0.125 | 0.406 | 4 | 0.5 |
| 276 | 59LE | 0.5 | | | | | | | | | | | 4 | 0.5 |

Dimensions of standard tool posts and shims.

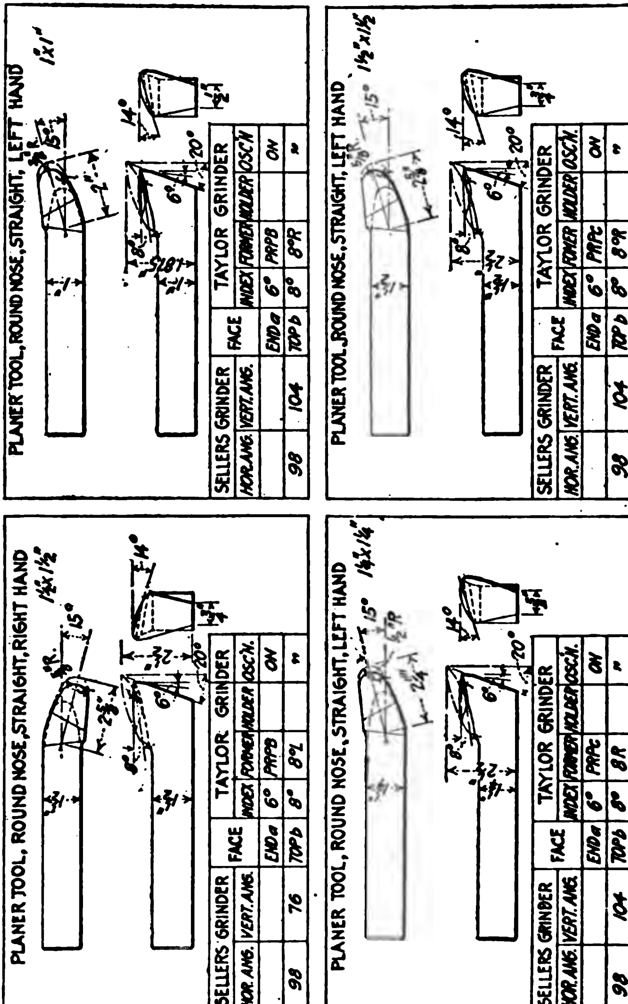



FIG. 73.—Standard round-nose planer tools.

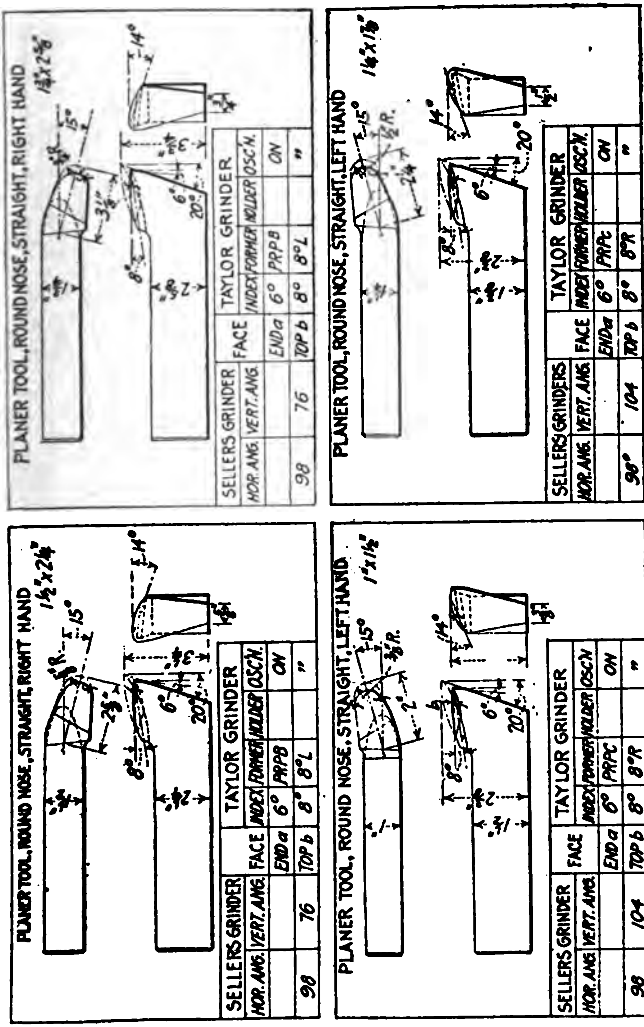



FIG. 74.—Standard round-nose planer tools.

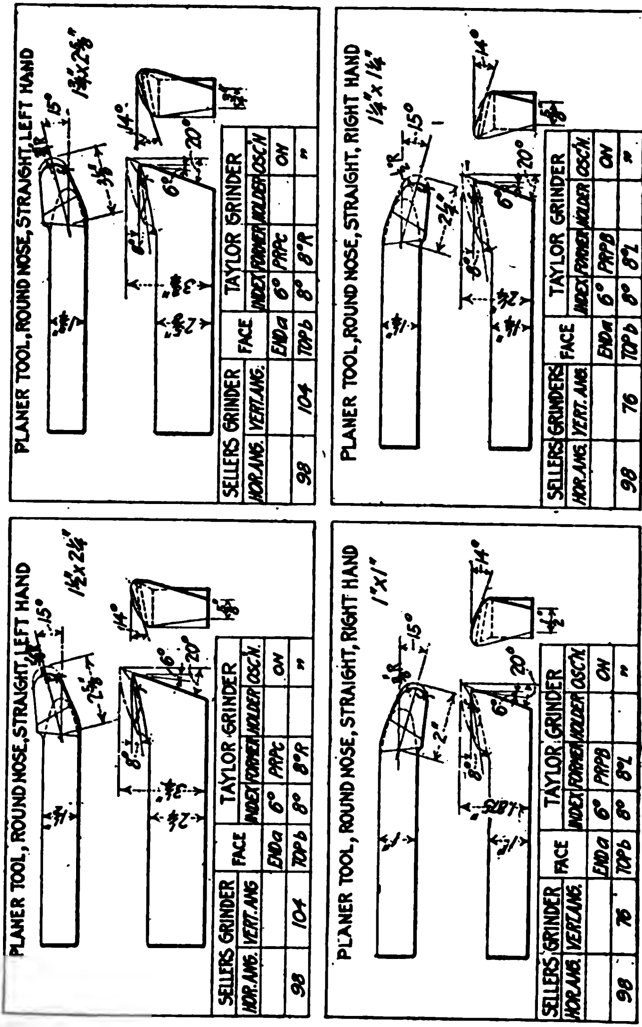



Fig. 75.—Standard round-nose planer tools.

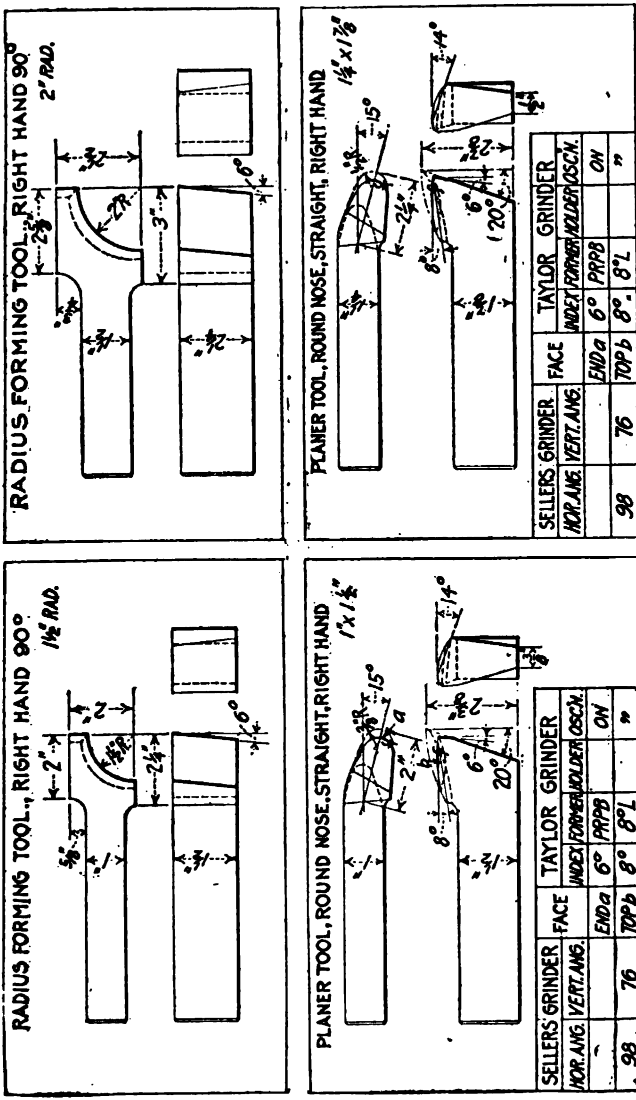



Fig. 76.—Standard round-nose planer tools and radius formers.

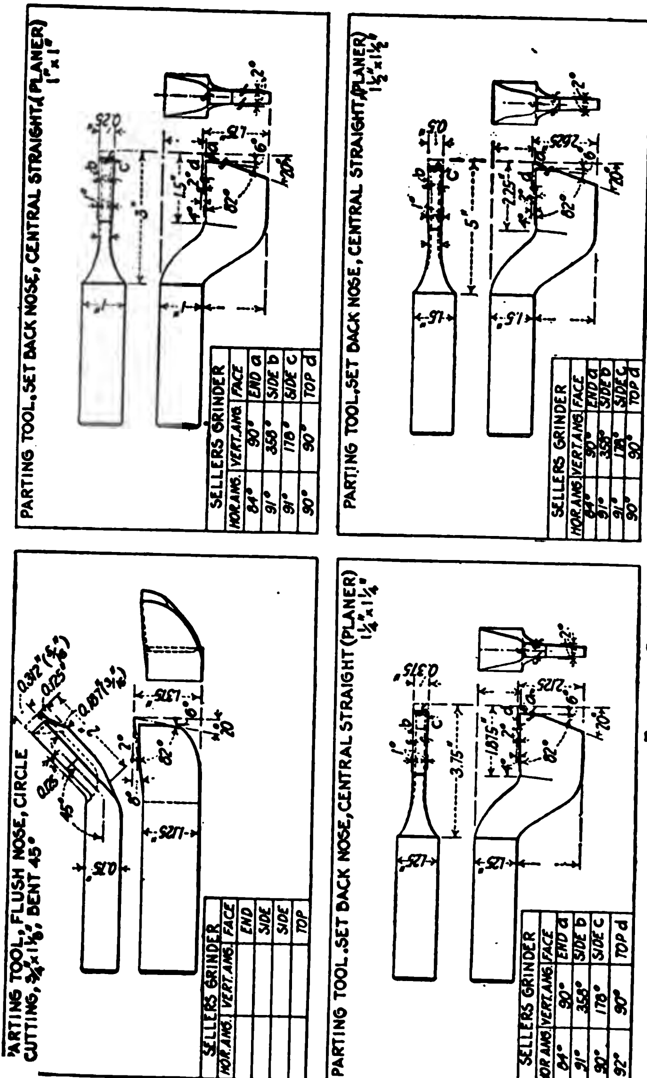
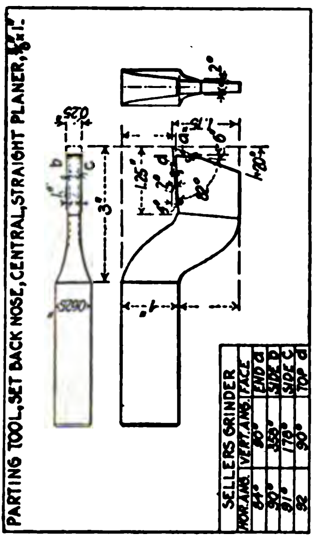
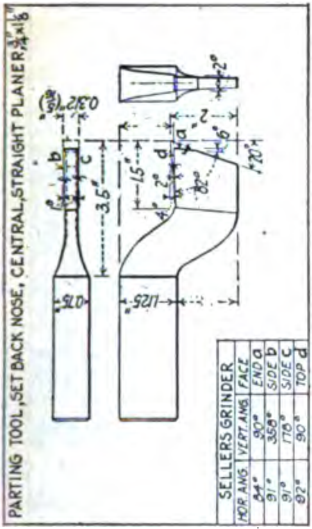
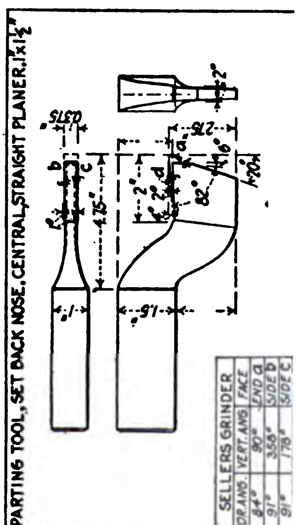
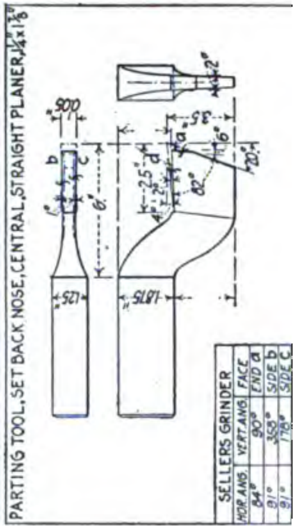



FIG. 77.—Standard parting tools for planers.

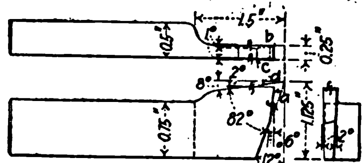

PARTING TOOL, SET BACK NOSE, CENTRAL, STRAIGHT PLANER, 5/8 x 1"
SELLERS GRINDER


PARTING TOOL, SET BACK NOSE, CENTRAL, STRAIGHT PLANER, 3/4 x 1 5/8"
SELLERS GRINDER


PARTING TOOL, SET BACK NOSE, CENTRAL, STRAIGHT PLANER, 1 x 1 1/2"
SELLERS GRINDER

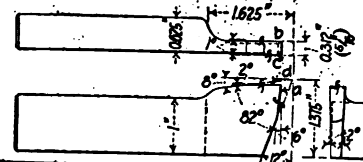

PARTING TOOL, SET BACK NOSE, CENTRAL, STRAIGHT PLANER, 1 1/4 x 1 7/8"
SELLERS GRINDER

PARTING TOOL, HIGH NOSE, RIGHT HAND, STRAIGHT, ½" × ¾"



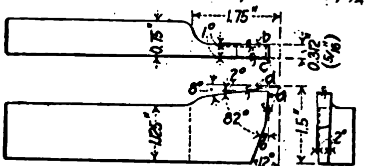
| SELLERS GRINDER | | | TAYLOR GRINDER | | | |
|---|---|---|---|---|---|---|
| HOR. ANG. | VERT. ANG. | FACE | INDEX | FORMER | HOLDER | OSC'N. |
| 84° | 90° | END a | 6° | 1 R | 1 | ON |
| 91° | 358° | SIDE b | 3° | 1° R | 3 | OFF |
| 91° | 178° | SIDE c | 3° | 1° L | 4 | ON |
| 92° | 90° | TOP d | 0° | 6° R | 3 | ON |

PARTING TOOL, HIGH NOSE, RIGHT HAND, STRAIGHT, ⅝" × 1"



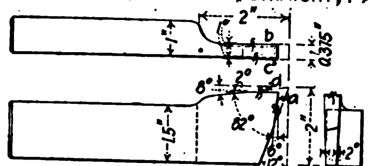
| SELLERS GRINDER | | | TAYLOR GRINDER | | | |
|---|---|---|---|---|---|---|
| HOR. ANG. | VERT. ANG. | FACE | INDEX | FORMER | HOLDER | OSC'N. |
| 84° | 90° | END a | 6° | 1 R | 1 | ON |
| 91° | 358° | SIDE b | 6° | 1° R | 3 | OFF |
| 91° | 178° | SIDE c | 3° | 1° L | 4 | ON |
| 92° | 90° | TOP d | 0° | 6 R | 3 | ON |

PARTING TOOL, HIGH NOSE, RIGHT HAND, STRAIGHT, ¾" × 1⅛"



| SELLERS GRINDER | | | TAYLOR GRINDER | | | |
|---|---|---|---|---|---|---|
| HOR. ANG. | VERT. ANG. | FACE | INDEX | FORMER | HOLDER | OSC'N. |
| 84° | 90° | END a | 6° | 1 R | 1 | ON |
| 91° | 358° | SIDE b | 3° | 1° R | 3 | OFF |
| 91° | 178° | SIDE c | 3° | 1° L | 4 | ON |
| 92° | 90° | TOP d | 0° | 6° R | 3 | ON |

PARTING TOOL, HIGH NOSE, RIGHT HAND, STRAIGHT, 1" × 1½"



| SELLERS GRINDER | | | TAYLOR GRINDER | | | |
|---|---|---|---|---|---|---|
| HOR. ANG. | VERT. ANG. | FACE | INDEX | FORMER | HOLDER | OSC'N. |
| 84° | 90° | END a | 6° | 1 R. | 1 | ON |
| 91° | 358° | SIDE b | 3° | 1° R | 3 | OFF |
| 91° | 178° | SIDE c | 3° | 1° L | 4 | ON |
| 92° | 90° | TOP d | 0° | 6 R | 3 | ON. |

FIG. 79.—Standard high-nose parting tools.

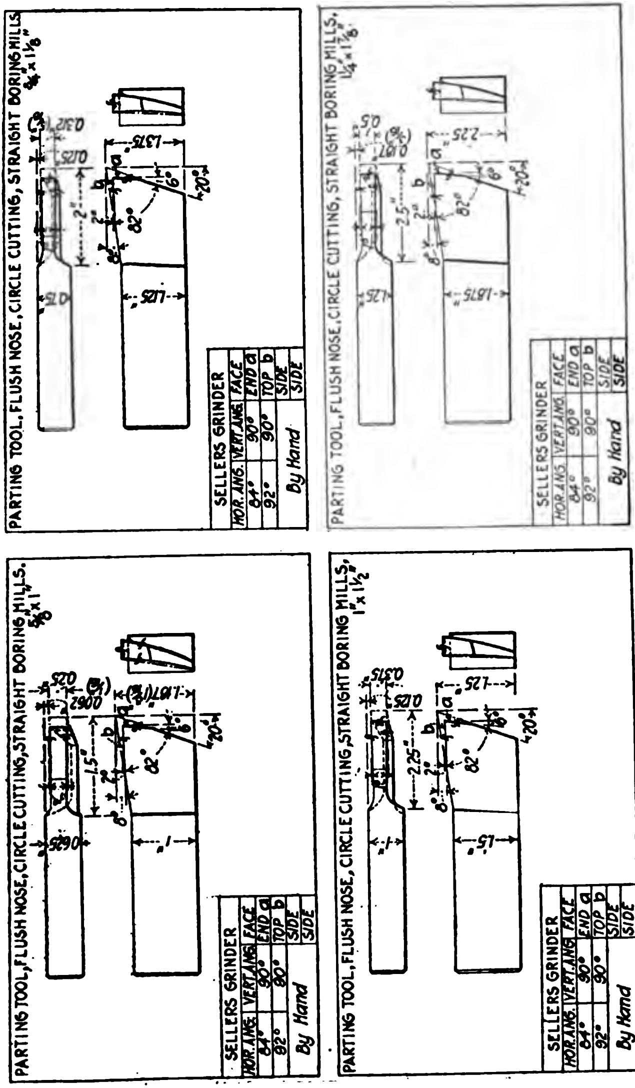
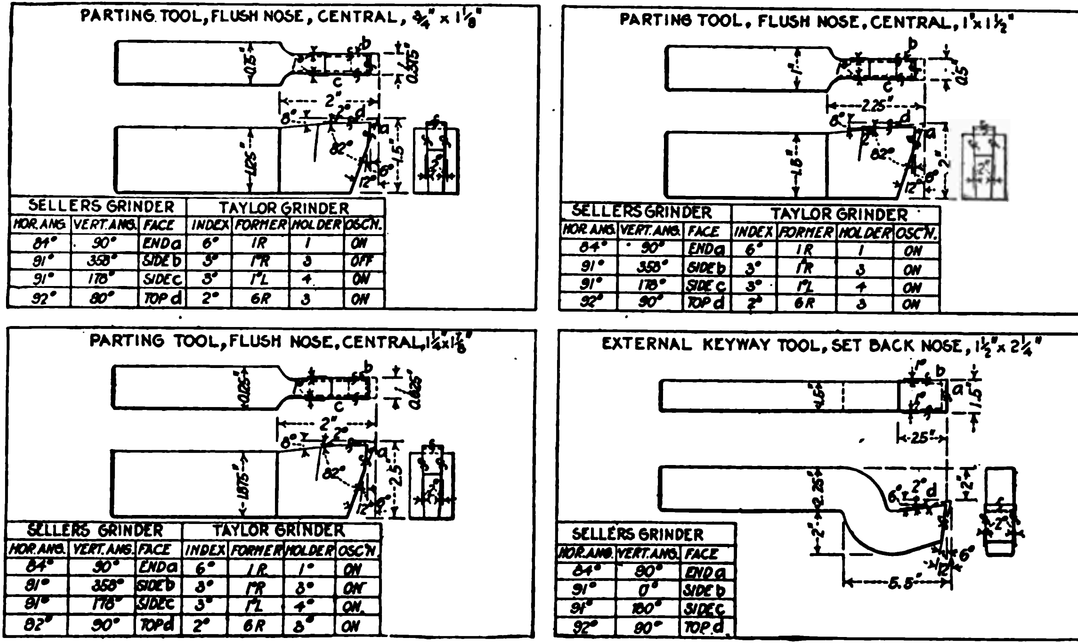



FIG. 80.—Standard boring mill parting tools.




**Parting tool, flush nose, central, 3/4" x 1 1/8"**

| SELLERS GRINDER | | | TAYLOR GRINDER | | | |
|---|---|---|---|---|---|---|
| HOR. ANG. | VERT. ANG. | FACE | INDEX | FORMER | HOLDER | OSC'N. |
| 84° | 90° | END a | 6° | 1R | 1 | ON |
| 91° | 358° | SIDE b | 3° | 1'R | 3 | OFF |
| 91° | 178° | SIDE c | 3° | 1'L | 4 | ON |
| 92° | 80° | TOP d | 2° | 6R | 3 | ON |

**Parting tool, flush nose, central, 1" x 1 1/2"**

| SELLERS GRINDER | | | TAYLOR GRINDER | | | |
|---|---|---|---|---|---|---|
| HOR. ANG. | VERT. ANG. | FACE | INDEX | FORMER | HOLDER | OSC'N. |
| 84° | 90° | END a | 6° | 1R | 1 | ON |
| 91° | 358° | SIDE b | 3° | 1'R | 3 | ON |
| 91° | 178° | SIDE c | 3° | 1'L | 4 | ON |
| 92° | 90° | TOP d | 2° | 6R | 3 | ON |

**Parting tool, flush nose, central, 1 1/4" x 1 7/8"**

| SELLERS GRINDER | | | TAYLOR GRINDER | | | |
|---|---|---|---|---|---|---|
| HOR. ANG. | VERT. ANG. | FACE | INDEX | FORMER | HOLDER | OSC'N. |
| 84° | 90° | END a | 6° | 1R | 1° | ON |
| 91° | 358° | SIDE b | 3° | 1'R | 3° | ON |
| 91° | 178° | SIDE c | 3° | 1'L | 4° | ON. |
| 82° | 90° | TOP d | 2° | 6R | 3° | ON |

**External keyway tool, set back nose, 1 1/2" x 2 1/4"**

| SELLERS GRINDER | | |
|---|---|---|
| HOR. ANG. | VERT. ANG. | FACE |
| 84° | 90° | END a |
| 91° | 0° | SIDE b |
| 91° | 180° | SIDE c |
| 92° | 90° | TOP d |

FIG. 81.—Standard boring mill parting tools.

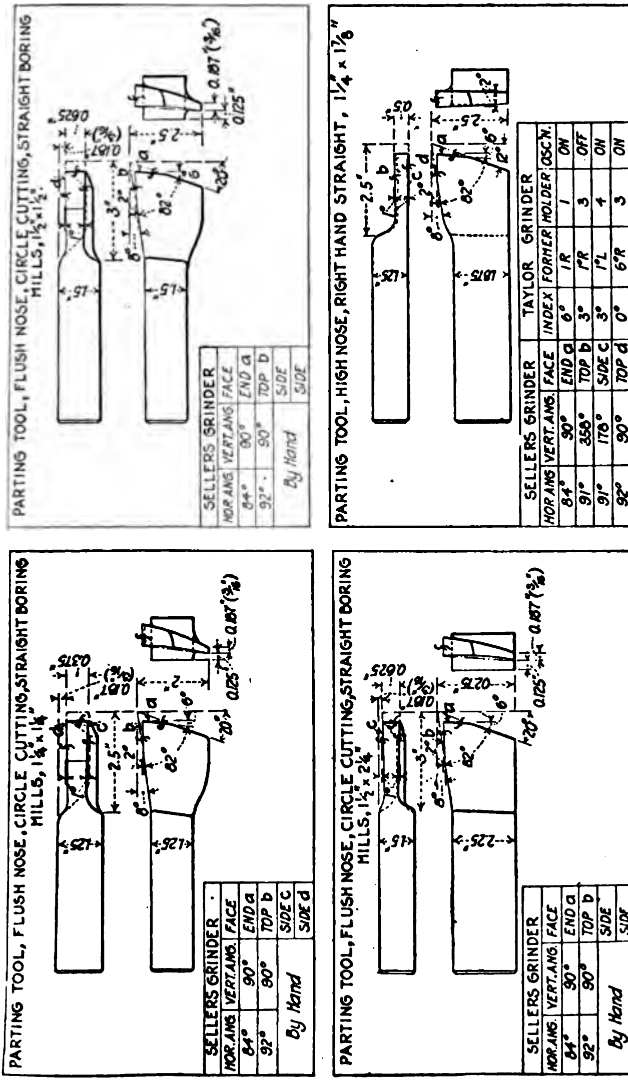



FIG. 82.—Standard boring mill parting tools.

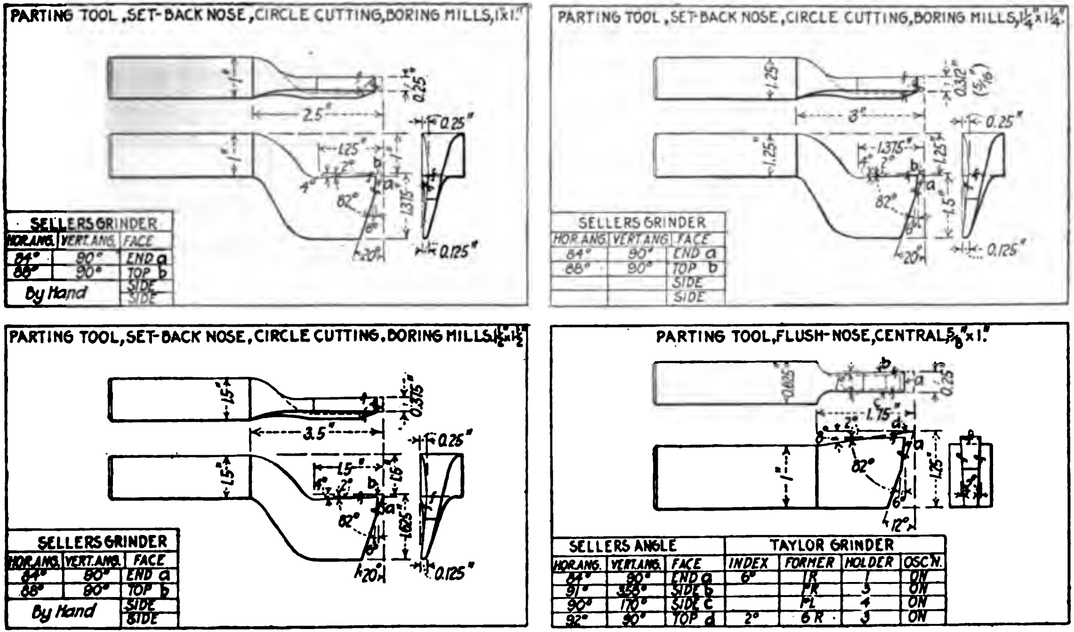



FIG. 83.—Standard boring mill parting tools.

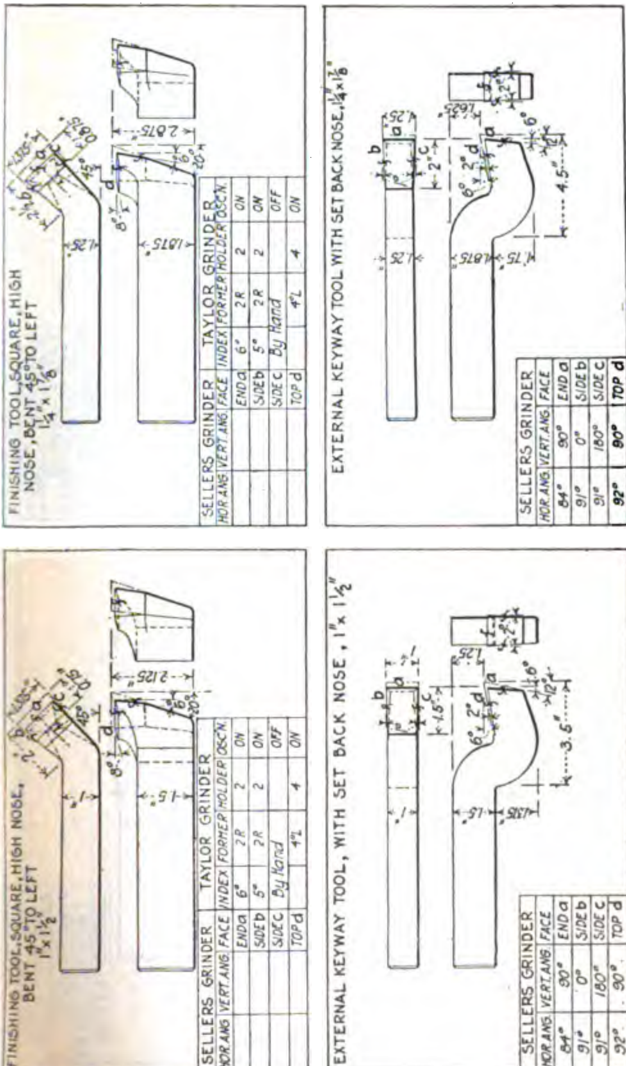



FIG. 84.—Standard planer finishing and external keyway tools.

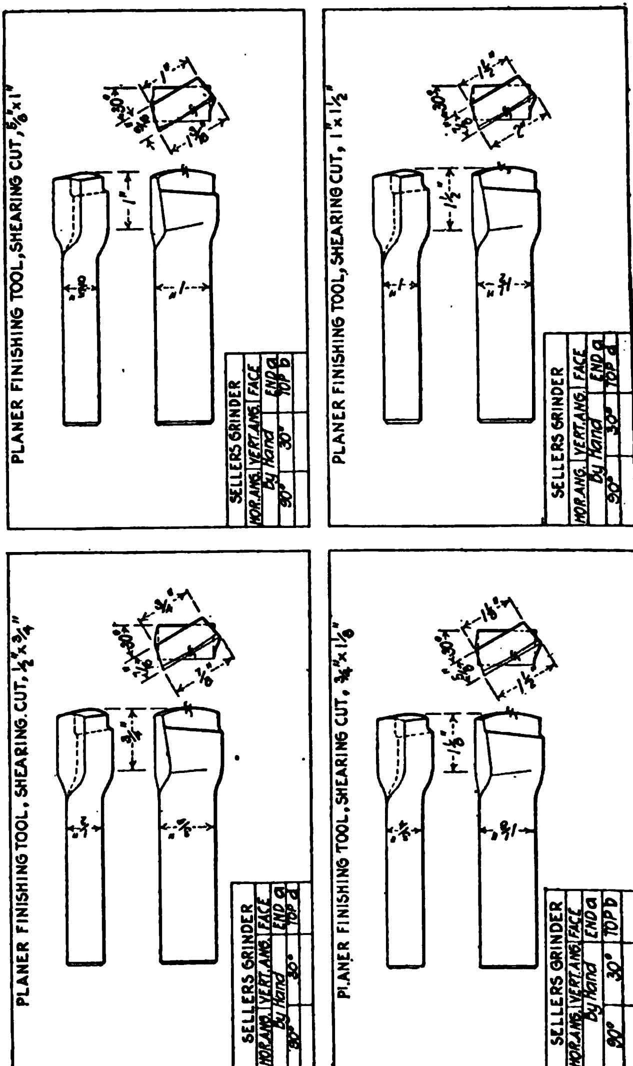



Fig. 85.—Standard shearing-cut finishing planer tools.

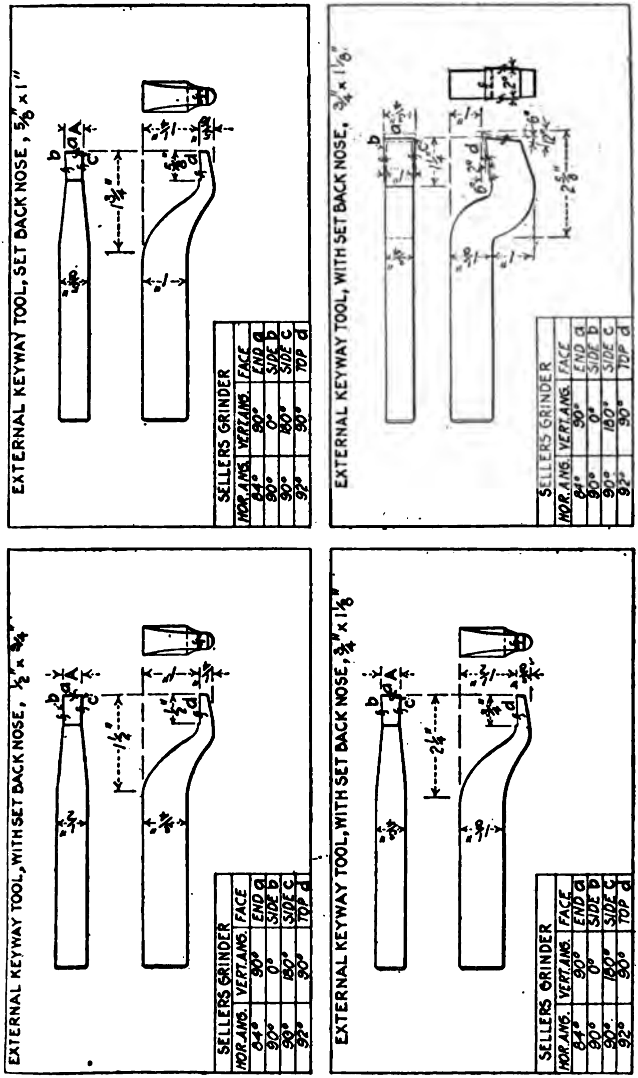



FIG. 86.—Standard external keyway tools.

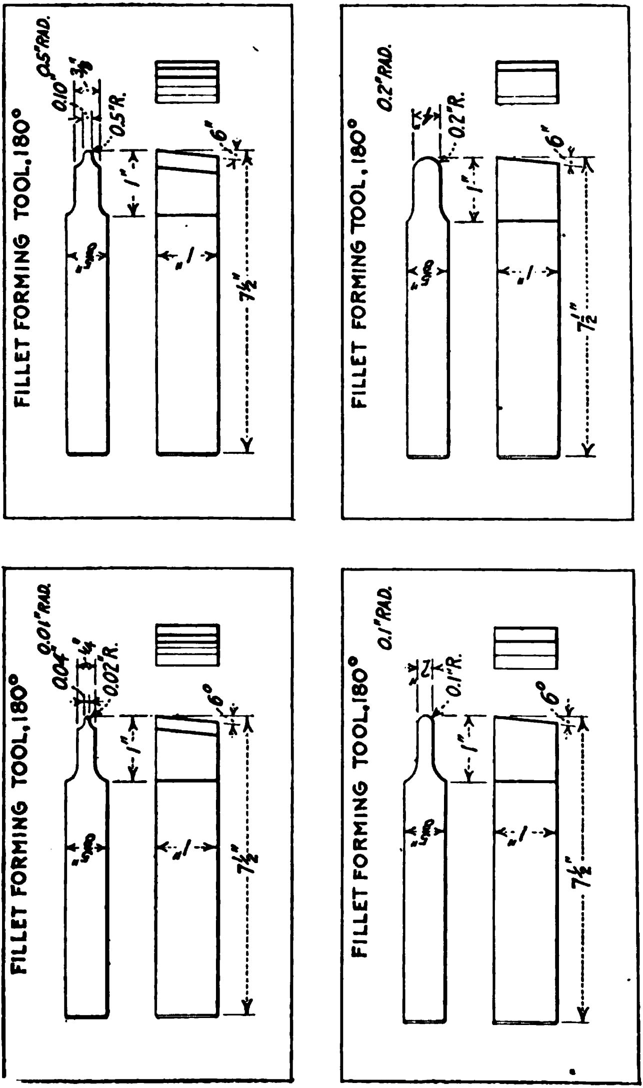
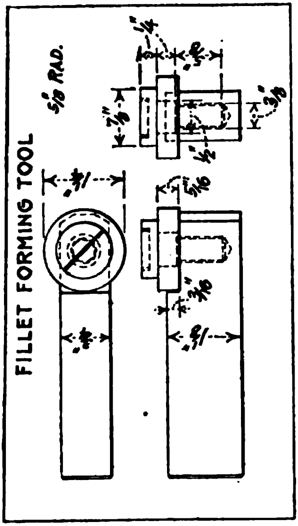
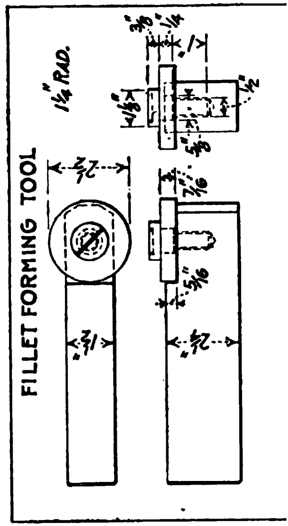
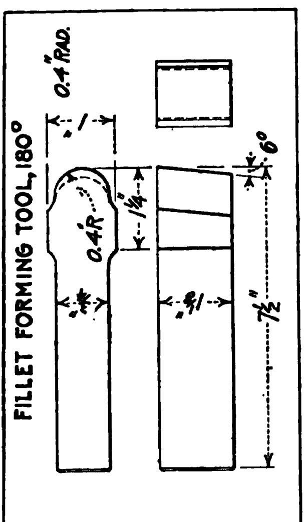
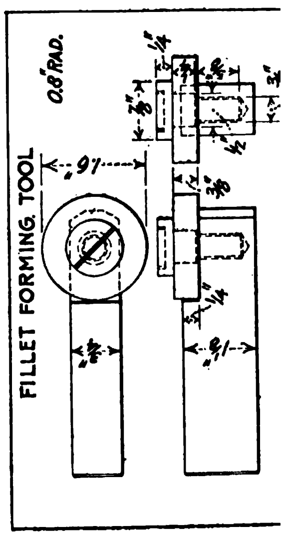



FIG. 87.—Standard fillet forming tools.


FILLET FORMING TOOL
5/8" RAD.


FILLET FORMING TOOL
1¼" RAD.


FILLET FORMING TOOL, 180°
0.4" RAD.
0.4" R


FILLET FORMING TOOL
0.8" RAD.

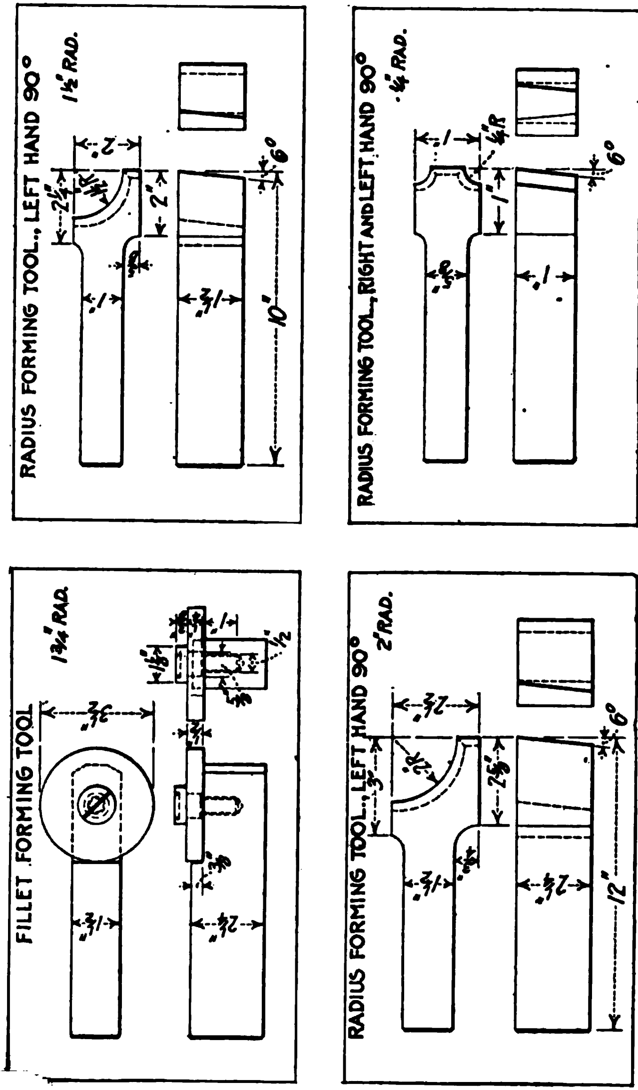
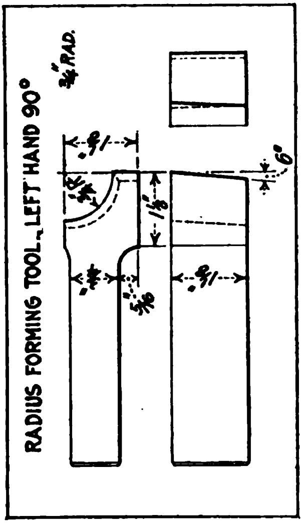
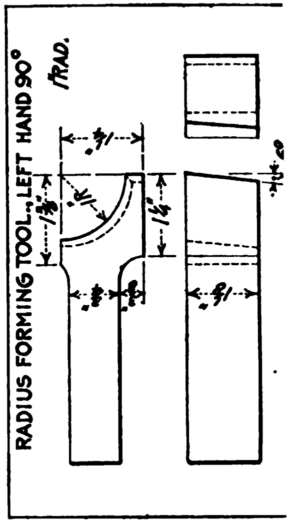
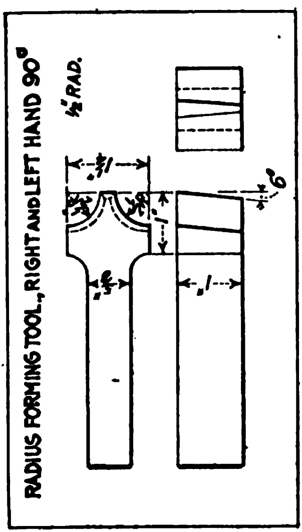
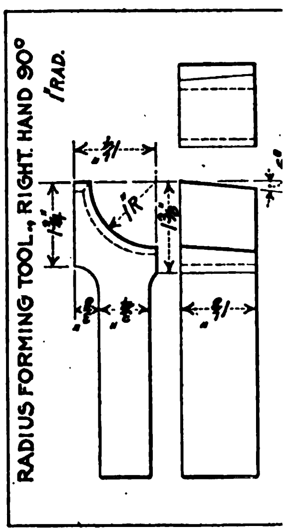



FIG. 89.—Standard fillet and radius forming tools.


RADIUS FORMING TOOL., LEFT HAND 90°
3/4" RAD.


RADIUS FORMING TOOL., LEFT HAND 90°
1" RAD.


RADIUS FORMING TOOL., RIGHT AND LEFT HAND 90°
1/2" RAD.


RADIUS FORMING TOOL., RIGHT HAND 90°
1" RAD.

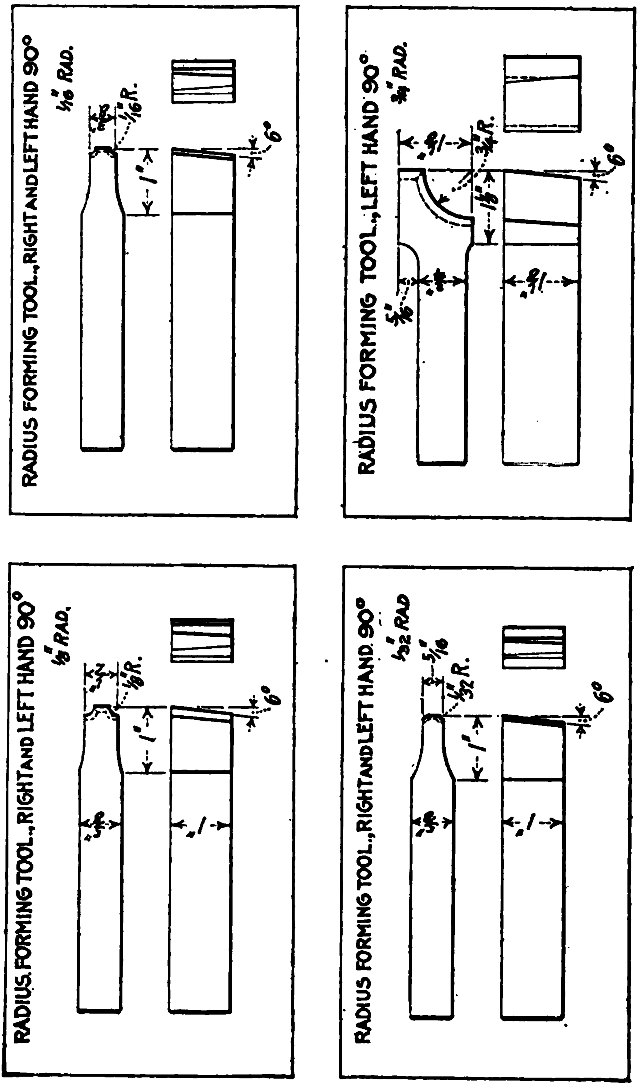
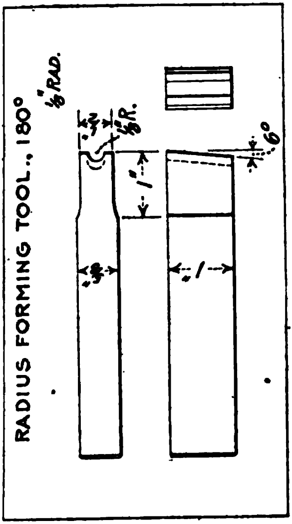
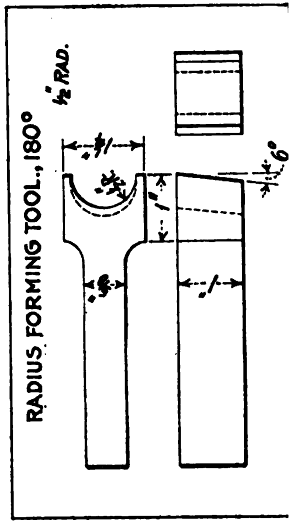
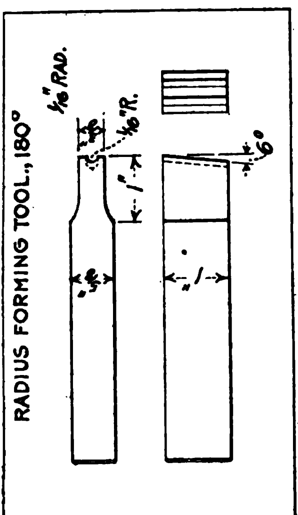
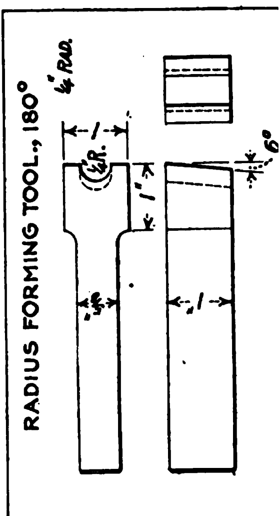



FIG. 91.—Standard radius forming tools.


RADIUS FORMING TOOL., 180°
1/8" RAD.
1/8" R.
1"
6°


RADIUS FORMING TOOL., 180°
1/2" RAD.
1"
6°


RADIUS FORMING TOOL., 180°
1/16" RAD.
1/16" R.
1"
6°


RADIUS FORMING TOOL., 180°
1/4" RAD.
1/4" R.
1"
6°

## PURCHASE METHODS

**178. Where the purchase requisition originates.** Purchasing is done for the shop, and the necessity of various purchases arises in the shop, to a large extent. Many plants conform to this fact in the matter of issuing requisitions. The stock-keeper, for example, would be the logical man to issue requisitions for material which is kept in his department. The superintendent would be the logical man to order new tools or equipment. The shop order clerk, who translates the customer's order into form for shop use, would be the logical man to order motors, or other foreign material which is to accompany the order. The chief engineer, or some one in his department, would be the proper one to requisition construction details which have to be purchased, and which are not on a standard list, such as special ball bearings, and material which is bought to special specification. The production clerk is the man to order purchases called for on a standard list but which are not carried in stock. The idea of this subdivision in ordering is to put it up to the man best qualified to do it, so that full information may be put on the requisition, and costly delays and mistakes avoided.

One difficulty in having so many sources of requisitions lies in the possible shifting of responsibility. This may be avoided only by defining the duties of each one distinctly, as shown in the graphical chart, Fig. 93.

**179. Forms of requisitions.** These vary from a plain sheet of paper or letter head addressed to the dealer and stating what is wanted to special requisition books which would be probably used in connection with a complete purchasing, receiving and inspecting system. In this case a form as shown in Fig. 94 could be used. It is necessary to have an original and five copies, all of which would be duplicates of the original except for color of paper, which would be different for each copy to distinguish them readily. These sheets would be perforated so as to be easily detached, and each series of original and copies would contain the same serial number printed upon them for identification.

**180. Requisitions should be made with spaces for:** Name and address of consignee. Name and address of consignee (other than the purchaser). Date of order. Method of shipment. Terms. Marking.

**181. How requisitions and copies are handled.** One copy should be retained by the maker of the requisition as evidence of the proper ordering of the material. The original is sent to the customer, unless conditions make it advisable to rewrite the order before sending it. In this case it is well to have the formal requisition letter-size and typewritten. One copy of this is retained for identification purposes and used in connection with the smaller requisition forms originating in the shop.

Requisitions for materials are checked off on the bill of material, if the purchase is for a specific order number. If for stock, this is impossible.

The purchase clerk may make use of copies of the requisition for cross-filing, to keep track and follow up purchases. One set for

example would be filed by serial number, for quick identification through correspondence and for information asked by the origina-

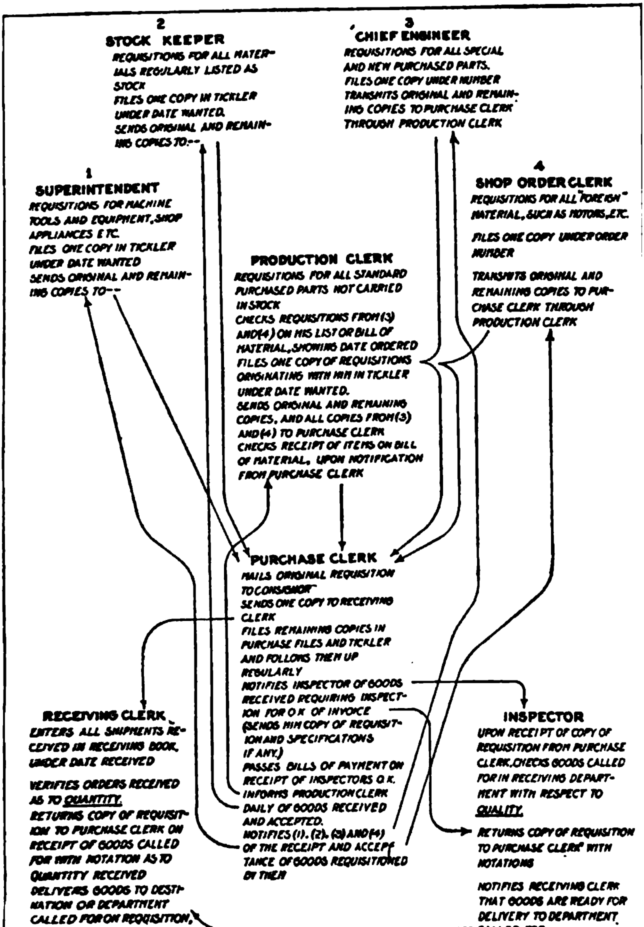



FIG. 93.—Graphical outline of duties in connection with purchasing.

tors of the order who find it more convenient to designate the order by the number. Another set of copies is filed under the names of the consignors or dealers, arranged alphabetically; another set by com-

modity, arranged alphabetically. Still another set is sometimes used in a tickler file, being arranged according to date called for. Several degrees of ticklers may be used, representing the degree of urgency. For example, tickler No. 1 contains orders which are not due; tickler No. 2 may contain those which are due but not delaying orders or work in the shop, while a third tickler may be used for urgently wanted jobs that are holding up shipments. The orders are transferred from one to the other as the state of urgency changes.

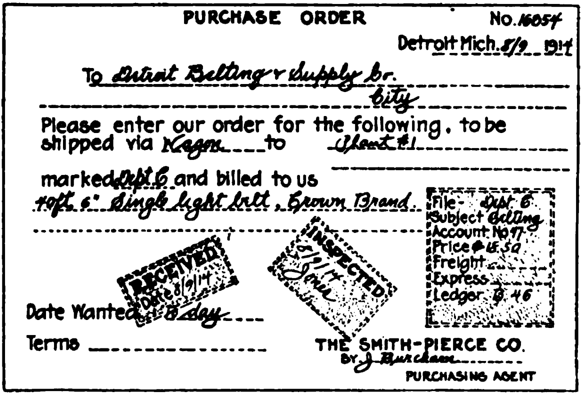

PURCHASE ORDER No. 16054
Detroit Mich. 8/9 1914
To Detroit Belting & Supply Co.
City
Please enter our order for the following, to be shipped via Wagon to Plant #1
marked Dept. 6 and billed to us
40 ft. 6" Single Light Belt, Brown Brand.
File- Dept. 6
Subject Belting
Account No. 17
Price
Freight
Express
Ledger B 46
RECEIVED Date 8/9/14
INSPECTED 8/9/14
Date Wanted 8 day
Terms
THE SMITH-PIERCE CO.
BY J. Burcham
PURCHASING AGENT

FIG. 94.—Purchase order form showing rubber stamp notations.

**182. Requisition system for the small shop.** No matter what the size of the plant, the following are necessary features of a good purchasing system:

(*a*) A purchase order.

(*b*) Inspection and count of goods received before bill is O.K.'d for payment.

(*c*) Information on the following points quickly available: Has the material been ordered, and from whom? What price was paid last time the goods were purchased? Have the goods been received, if so when? Has the bill been paid, and when? How much of this material has been bought in a given period?

The small shop has the advantage over the larger one that there will be but few purchase orders active at any one time, therefore the method of filing these active orders may be simplified and fewer copies required. In the small shop a letter head may be employed for the requisition, two copies being made from it. One of these is placed in the general files for safe-keeping, the other is used for active tracing, noting receipt, condition of goods, price and so on. If but one kind of commodity is ordered on an order, these forms will be well adapted to classification after the order is filled by filing them under any desired heading, for example, commodity and department used, in which case they will form a record of consumption of the material in question. If prices are marked upon these copies they will also

serve as a price index in making purchases. This scheme would prove too cumbersome for the large plant on account of the greater number of orders, but can be used to advantage by the small plant with great economy in the matter of records. Owing to the uniform sheet sizes, data from bills which vary in size and are not so easily filed should be transferred to this copy.

In the small plant, one man may often perform all the functions connected with purchasing, receiving, inspecting and so on. A

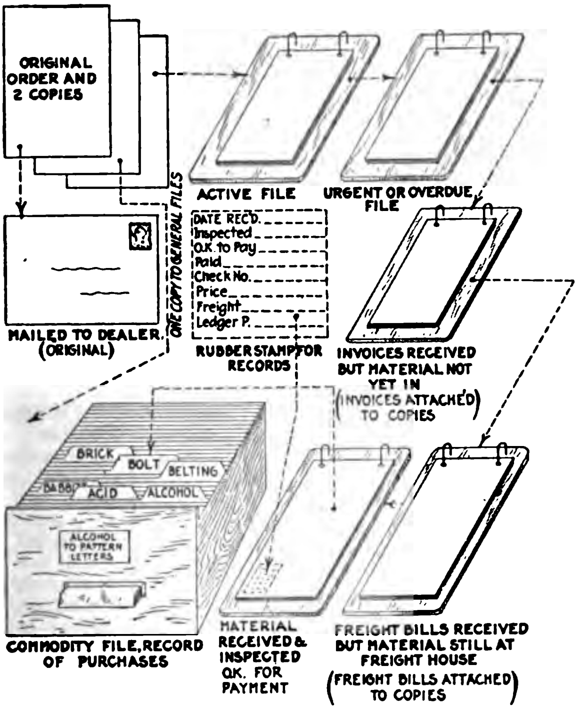



FIG. 95.—A simple purchase order system for the small shop.

system which is adapted to needs of this kind is illustrated in Fig. 95.

**183. Expediting the filling of purchase orders.** Every manufacturer knows, although he does not like to admit it, that during rush times the customer who does the least kicking usually gets the slowest service. While this condition is an unfortunate one, it exists and must be recognized. Therefore if we are to secure prompt service in the shipment of purchased orders, they must be systematically followed up. A convenient way to record the results of

such methods is to provide space on the back of the requisition for the date of writing and the promise of shipment received in return. Fig. 96 illustrates this. To save time in writing for the information, form postal-cards are often used, as shown in Fig. 97. All requisitions should specify the date when the material will be wanted, and request immediate notification with the acknowledgment of the order, if the date cannot be kept. Overdue orders should be kept in an active file or folder and followed up with varying degrees of frequency according to their urgency. A list of all purchase orders which are actually holding up shipments should be prepared every day and handed to the manager. Post cards, telegrams and telephone communication represent different degrees of urgency, the latter being the most satisfactory means of taking the matter "higher up." The percentage of total delays occasioned by slow delivery of purchased materials is a large one during busy times, and the slight expense in clerical effort necessary to keep track of these things systematically is small compared with its effect.

Order Acknowledged 2/14/14

Original Promise of Shipment 3/20/14

| Traced | Promised |
|---|---|
| 3/20/14 Card | 3/28/14 |
| 3/28 Wire | 4/2/14 |
| 3/30 Wired Reship by express holding order 6441 | 4/2/14 |
| | |
| Received | 4/3/14 |
| | |
| | |
| | |
| | |
| | |
| | |

FIG. 96.—Back of purchase order, showing delivery notations and follow up.

Gentlemen—

Please refer to our order number ...... calling for ______________________

which is now due.

Advise by return mail earliest possible shipping date on this material.

Yours Very Truly
Standard Mfg. Co.
by ..........

FIG. 97.—Return postal card calling for shipping date.

**184. Price index and records.** A record of every quotation received for material to be purchased, and a classified record of the price of the material actually purchased should be kept, as it is of great aid when occasion requires the purchase of the same commodity again or a similar one. One simple way to do this is to make use of the copy of the

purchase requisition mentioned above, which does away with the need of an additional form for this purpose. However, some firms prefer to use a small card index for more convenient reference. The material entered should include date, name of concern making the price, commodity, quantity, price, and whether delivered, or F.O.B. source.

**185. Taking advantage of the cash discount.** Everyone who is connected with purchasing knows of the customary practice of allowing a cash discount, usually 2 per cent. for payment of the account within 10 days. Sometimes this is not clearly understood in the shop, the result being that inspection reports and acceptances of new material are made too late to take advantage of the discount. This 2 per cent. is so easily made and with so little expenditure of effort that it is a shame to lose it. All of those having to do with the acceptance of materials should be made to realize the importance of prompt reports with this end in view.

**186. Purchased material units.** The following lists of purchased material and the units in which the various commodities are purchased was compiled from the purchase records of a large manufacturing plant. It is of value in establishing a standard of units for inventory, so that the inventory reports may be priced consistently. Also in arranging purchase accounts, or indexing a purchase ledger.

| Article | Unit |
|---|---|
| A. Alcohol | Gallon. |
| Alcohol denatured | Gallon. |
| Asbestos | Square yard. |
| Acids, nitric | Pound. |
| Acids, muriatic | Pound. |
| Acids, sulphuric | Pound. |
| Acids, hydrofluoric | Pound. |
| Acids, hydrochloric | Pound. |
| Aluminum | Pound. |
| Antimony | Pound. |
| Asphaltum | Pound. |
| Axes | Each. State size. |
| B. Babbitt | Pound. |
| Bags | Each. |
| Burlaps | Each. |
| Bronze ingot | Pound. |
| Ball bearings | Each. State size. |
| Brass ingot | Pound. |
| Brass scrap | Pound. |
| Bellows | Dozen. |
| Belting | Foot. |
| Belt dressing | Pound. |
| Belt cement | Pound. |
| Belt lacing | Each or foot. |
| Bibbs, compression | Each. |
| Banding, cotton | Pound. |
| Bismuth | Pound. |
| Borax | Pound. |
| Beeswax | Pound. |
| Boiler tube | Foot. |
| Bolts, carriage | Per 100. State length and diam. |
| Bolts, machine and tap | Per 100. State head, length and diam. |
| Bolts, hex head | Per 100. State head, length and diam. |
| Bolts, tire | Per 100. State head, length and diam. |

| | Article | Unit |
|---|---|---|
| B. | Bolts, stud | Per 100. State length, diam. |
| | Bolts, stove | Per 100. State length, diam. |
| | Bolts, Whitworth | Per 100. State length, diam. |
| | Bolts, expansion | Each. State length, diam. |
| | Bolts, eye | Each. State number and cut. |
| | Brick | Per 1000. State size. |
| | Buffing wheels | Each. State diam. and face. |
| | Buffing cottons | Each. State diam. and face. |
| | Brooms | Dozen. State size. |
| | Brushes, paint | Dozen. State size and No. |
| | Brushes, glue | Dozen. State size and No. |
| | Brushes, oil or bench | Gross. State size. |
| | Brushes, lathe or dust | Gross. State size and kind. |
| | Brushes, floor | Each. State size. |
| | Brushes, molders | Dozen. State size. |
| | Buckets, iron and coal | Each. |
| C. | Cellar drainers | Each. State size. |
| | Covers, canvass | Each. Size and number. |
| | Calcium chloride | Pound. |
| | Casks, empty | Each. |
| | Charcoal | Bushel. |
| | Cement | Pound. |
| | Stove lining | Pound. |
| | Chaplets | Per 100. State size and kind. |
| | Cloth-crocus | Ream. |
| | Chalk | Pound. |
| | Chisels | Doz. State size and style. |
| | Corks | Gross. State size. |
| | Core binders | Pound. |
| | Core wash | Pound. |
| | Core oil | Gallon or pound. |
| | Cotters, spring | Per 1000. State number and length. |
| | Coal, blacksmith | Pound or ton. Net. |
| | Coal, hard | Pound or ton. Net. |
| | Coal, soft | Pound or ton. Net. |
| | Clay, fire | Pound. |
| | Cocks | Each. Style and size. |
| | Coke, foundry | Ton. Net. |
| | Copper | Pound. |
| | Copper sheet | Pound. |
| | Copper rivets and burrs | Pound. State size. |
| | Crow bars | Each. State size or number. |
| | Clutches, friction | Each. State style and size. |
| | Crucibles | Each and pounds. |
| D. | Door mats | Each. |
| | Dowell pins | Doz. State diameter. |
| | Dowell, shoulder | Per 100. State diameter. |
| | Dowell, plate brass | Gross. State diameter. |
| | Dowell, wood | Per 100. State diameter and length. |
| | Diaphragms | Each. State size. |
| E. | Electrical Supplies: | |
| | Battery cells | Each. State style and size. |
| | Switches | Each. State style and size. |
| | Fuses | Each. State style and size. |
| | Wire | Pounds. State gage and style. |
| | Cord | Foot. State size and kind. |
| | Receptacles | Each. State size and style. |
| | Controller parts | Each. State size and style. |
| | Silk and cotton cord | Feet. State size and style. |
| | Lamps | Each. State size and style. |
| | Emery wheels | Each. Length, bore, face, grade. |
| | Emery blocks | Each and pound. |
| | Emery wheel dressers | Per 100. |
| | Emery cloth and paper | Ream or sheet, state size. |
| | Emery powder | Pound. |

| Article | Unit |
|---|---|
| E. Excelsior | Pound. |
| F. Floats | Each. State size and type. |
| Funnels | Each. State size. |
| Foundry supplies: | |
| Flour | Per ton or cwt. |
| Phosphoro | Pound. |
| Plumbago | Pound. |
| Shovels | Dozen. |
| Seacoal | Pound. |
| Flax swabs | Dozen. |
| Talc | Pound. |
| Mineral facing | Pound. |
| Graphite | Pound. |
| Riddles | Dozen. |
| Felt | Square foot. |
| Fiber | Give dimensions. |
| Filter stones | State size. |
| Files | Dozen. |
| (On files state kind, square, round, second cut, bastard, mill, etc., length also must be stated.) | |
| Fillet, leather | Per 1000 ft. |
| Fillet, wood | Per 100 ft. |
| Fire brick | Per 1000. Size. |
| Fusible plugs | Each. |
| Forks, coke | Each. |
| G. Glaziers points | Pound. State number. |
| Gasoline | Gallon. |
| Gaskets | Each. State kind and size. |
| Glass | Light. Size and gage. |
| Glue | Pound. |
| Grease | Pound. |
| Grease cups | Each. Size and kind. |
| Grind stones | Pound. |
| H. Hammers | Dozen. State number. |
| Handles | Dozen. State size. |
| Hangers, shafting | Each. State size. |
| Hooks | Each. State size or number. |
| Hinges | Pair or pound. State size. |
| Hose, suction | Foot. State size and ply. |
| Hose, discharge | Foot. State size and ply. |
| Hose, air | Foot. State size and ply. |
| Hose, rubber C. I. tube | Foot. State size and ply. |
| Hose, cotton and linen | Foot. State size and ply. |
| Hose clamps | Gross. State size. |
| Hose bands | Gross. State type and size. |
| Hose coupling | Dozen. State brass or iron and size. |
| Hose holders | Each. State type. |
| Hose menders | Dozen. State size. |
| Hardware | Each. Description. |
| I. Iron, sheet | Pound. Gage. |
| Iron, structural | Pound. |
| Iron, bar | Pound. Size. |
| Iron, band | Pound. Size. |
| Iron, scrap | Pound. |
| Iron filler, smooth on | Pound. |
| J. Jack screws | Each. Size. |
| Japan drier | Pound. |
| K. Keys, Woodruff | Each. Letter and size. |
| Knives | Dozen. Size. |
| L. Lath metal | Sq. ft. |
| Lawn mowers | Each. Size and type. |
| Lamps | Each. Size. |
| Lamp wicks | Dozen. |
| Litharge | Pound. |
| Lawn sprinklers | Each. |

| | Article | Unit |
|---|---|---|
| L. | Lacquer | Gallon. |
| | Lamp guards | Each. Number. |
| | Lamp black | Pound. Kind. |
| | Leather | Pound. Kind. |
| | Lead, pig | Pound. |
| | Lead, sheet | Pound. |
| | Lime | Pound |
| | Limestone | Perch. |
| | Lycopodeum | Pound. |
| | Lumber | 1000 bd. ft. Kind, size, thick. |
| | Ladders | Foot. Kind. |
| | Ladders step | Each. |
| M. | Mallets | Dozen. Length and diameter. |
| | Mallets with handles | Dozen. |
| | Malleable castings | Number and weight. |
| | Mica, flake | Pound. |
| | Motors | Each. Order number. |
| | Starters and switches | Each. Order number. |
| N. | Nails | Pound. Size (penny). |
| | Nails, cut | Pound. Size (penny). |
| | Nails, copper | Pound. Size. |
| | Nails, wire | Pound. Size. |
| | Nails, cement coated | Pound. Size. |
| | Nails, wire brads | Pound. Size. |
| | Nameplates | Each. State style. |
| | Naphtha | Gallon. |
| | Nipples | Each. Style. |
| | Nozzles | Each. Size. |
| | Sprinklers | Each. |
| | Nuts, check | Pound. Size. |
| | Nuts, cold punched | Pound. Size. |
| | Nuts, semi-finished | Pound. Size. |
| | Nuts, hot pressed | Pound. Size. |
| | Nuts, thumb screw | Pound. Size. |
| | Nuts, brass | Per 100. Size. |
| O. | Oatmeal | Pound. |
| | Oils, paraffine | Gallon. |
| | Oil, paraffine wax | Pound. |
| | Oils, linseed raw | Gallon. |
| | Oils, linseed boiled | Gallon. |
| | Oils, sperm | Gallon. |
| | Oils, castor | Gallon. |
| | Oils, kerosene | Gallon. |
| | Oils, neat's foot | Gallon. |
| | Oils, lubricating vaseline | Pound. |
| | Oils, lubricating non-fluid | Pound. |
| | Oils, lubricating screw cutting | Gallon. |
| | Oils, lubricating, lard | Gallon. |
| | Oils, fish | Gallon. |
| | Oilers | Each. Fig., size and make. |
| | Oilers capillary | Each. Fig., size and make. |
| | Oilcans | Each. Fig., size and make. |
| P. | Phosphoro | Pound. |
| | Pails | Dozen. Size. |
| | Pins | Gross. Size. |
| | Pitch | Pound. |
| | Plaster of Paris | Pound. |
| | Packing, hydraulic | Pound. Size. |
| | Packing, rubber | Pound. Size and kind. |
| | Packing, flax | Pound. Size and kind. |
| | Packing, flax treated | Pound. Size and kind. |
| | Packing, hemp | Pound. Size and kind. |
| | Packing, wick | Pound. Size and kind. |
| | Packing, paper board | Bundle. Size and kind. |
| | Packing, strawboard | Sheet. Size and kind. |

| Article | Unit |
|---|---|
| P. Paper, toilet | Roll. |
| Paper, toilet, holders | Dozen. |
| Paper, wrapping | Pound. |
| Plaster, wood fiber | Bag. |
| Paper, roofing | Roll. Ply. |
| Paint, interior cold water | Pound. |
| Paint, roofing | Gallon. |
| Paint, machinery | Pound. |
| Paint, steel filler | Pound. |
| Paint, bronze | Pound. |
| Paint, aluminum bronze | Gallon. |
| Paint, gold leaf | Books. |
| Pattern letters | Each. Style and size. |
| Pig iron | Ton (short). |
| Pig iron, charcoal | Ton (short). |
| Poles | Per 100, size. |
| Pipe, spiral riveted | Foot. Size. |
| Pipe, asphalted | Foot. Size. |
| Pipe, pullers | Each. Size. |
| Pipe, gas pipe | Foot. Size plain or galv. |
| Pipe, lifters | Each. |
| Pipe, fittings | Each. Size and style. |
| Bushings | Each. Size and style. |
| Couplings | Each. Size and style. |
| Elbows | Each. Size and style. |
| Lock nuts | Each. Size and style. |
| Bends | Each. Size and style. |
| Flanges | Each. Size and style. |
| Flange unions | Each. Size and style. |
| Nipples | Each. Size and style. |
| Sockets | Each. Size and style. |
| Tees | Each. Size and style. |
| Thread protectors | Each. Size and style. |
| Reducers | Each. Size and style. |
| Unions, malleable | Each. Size and style. |
| Crosses | Each. Size and style. |
| Caps | Each. Size and style. |
| Pulleys | Each. Size. |
| (On pulleys, state face, diam. | bore, and whether loose or tight. State |
| whether steel, iron, or wood.) | |
| Pulley blocks | Each. Size and style. |
| Polish | Pound. |
| Putty knives | Dozen. |
| R. Rags, wipers, etc. | Pound. |
| Rawhide pinions | State diam. face, bore. |
| Red lead | Pound. |
| Rivets | Pound. |
| Revolution counters | Each. Size and style. |
| Rosin | Pound. |
| Rods, brass cased | Pound. Diam. and length. |
| Rods, case hardened | Each. Fig. and size. |
| Rods, round brass | Pound. Diam. and length. |
| Rods, square brass | Pound. Size and length. |
| Rods, bronze | Pounds. Diam. and length. |
| Rods, galvanized | Pound. Size. |
| Rod couplings | Pound. Size. |
| Rope | Pound. Size. |
| Rust preventative | Gallon. |
| Rubber bumpers | Pound. Size. |
| Rubber cord | Pound. Size. |
| Rubber mattings | Pound. |
| S. Sash weights | Per 100. |
| Sal ammoniac | Pound. |
| Sal ammonia | Pound. |

| | Article | Unit |
|---|---|---|
| S. | Sal soda | Pound. |
| | Soda ash | Pound. |
| | Sand, molding | Ton. |
| | Sand, fire | Ton. |
| | Sand paper | Ream or sheet. Size and number. |
| | Sand, core, No. 2 | Ton. |
| | Saws | Each. Size and style. |
| | Strainers | Each. Size and style. |
| | Shellac | Pound. |
| | Screw hooks and eyes | Gross. Size. |
| | Screws, machine | Gross. Size and number. |
| | Screws, machine brass | Gross. Size and number. |
| | Screws, can | Gross. Size and number. |
| | Screws, lag or coach | Per 100. Size and number. |
| | Screws, case hardened set | Per 100. Size and number. |
| | Screws, wood | Gross. Size and number. |
| | Screws, R. H. wood | Gross. Size and number. |
| | Screen boxes | Each. |
| | Sulphur | Pound. |
| | Sheet brass | Pound. Size sheet and gage. |
| | Spelter | Pound. |
| | Silver metal | Pound. |
| | Shaft couplings | Each. Size and style. |
| | Shaft drop hangers | Each. Size and style. |
| | Springs | Each. Size and dimensions. |
| | Steel castings | Pound. Size and number. |
| | Steel, cold rolled | Pound. Size. |
| | Steel, crucible | Pound. Size. |
| | Steel, hammered crucible | Pound. Size. |
| | Steel, soft, round | Pound. Size. |
| | Steel, soft, squares and flats | Size. Dimensions. |
| | Steel, tool, round | Pound. Dimensions, make, grade. |
| | Steel, tool squares | Pound. Dimensions, make, grade. |
| | Steel, tool, flats, hex. and oct. | Pound. Dimensions, make, grade. |
| | Steel disks | Each. Size. |
| | Steel rails | Ton. |
| | Steel sheet | Pound. Size and gage. |
| | Steel spring | Pound. Size. |
| | Spring copper | Pound. Size. |
| | Scrap steel | Pound. |
| | Steel, band | Pound. |
| | Stencils | Each. |
| | Straps, leather | Each. Size. |
| | Signs | Each. Size and type. |
| | Sinks | Each. Size and Fig. |
| | Straw | Ton. |
| | Stone | Perch, or ton. Description. |
| | Soap | Case or bar. Brand. |
| | Soapstone crayons | Gross. |
| | Spokes | Each. |
| T. | Turnbuckles | Each. Size. |
| | Tacks, carpet | Pound. Size. |
| | Triopli | Pound. |
| | Tanks | Each. Size. |
| | Tank floats | Each. Number and size. |
| | Tallow | Pound. |
| | Taper pins | Per 100. Number and length. |
| | Tapes, measuring | Each. Length. |
| | Tin, pig | Pound. |
| | Tin, sheet | Pound. |
| | Tin, phosphor | Pound. |
| | Tubing, brazed brass | Pound. O.D. Gage. |
| | Tubing, seamless | Pound. O.D. gage. |
| | urpentine | Gallon. |
| | rmit | Pound. |

| Article | Unit |
|---|---|
| T. Tubes, aluminum | Pound. Pipe size. |
| Tubes, copper seamless | Pound. Pipe size. |
| Twine | Pound. |
| Tags | Per 1000. Size and kind. |
| V. Valves | Each. Style and size. |
| Air | Each. Style and size. |
| Tank float | Each. Style and size. |
| Blow off | Each. Style and size. |
| Foot | Each. Style and size. |
| Water relief | Each. Style and size. |
| Gate | Each. Style and size. |
| Brass hose | Each. Style and size. |
| Globe | Each. Style ank size. |
| Gross | Eech. Style and size. |
| Angle | Each. Style and size. |
| Check | Each. Style and size. |
| By pass | Each. Style and size. |
| Valve disks, canvas | Each. Style and size. |
| Rubber | Pound. Number and size. |
| Ammonia | Pound. Number and size. |
| Leather | Pound. Number and size. |
| Fiber | Pound. Number and size. |
| Varnish | Gallon |
| Dipping | Gallon |
| Brush | Gallon |
| Vises | Each. Number and size. |
| W. Wax, floor | Pound. |
| Wagons | Each. Kind. |
| Waste | Pound. |
| Washers | Pound. |
| Welding plates | Per 100. Size. |
| Welding compound | Pound. |
| Well points | Gross. Size and style. |
| Wrenches | Each. Size and style. |
| Wrenches, drop forged | Each. Size and number. |
| White lead in oil | Pound. |
| Whiting | Pound. |
| Wheels | Each. Diam. and tread. |
| Whistles | Each. |
| Wire cloth | Roll. Feet. |
| Wire, spring steel | Pound. Gage. |
| Wire, music | Pound. Gage. |
| Wire, iron | Pound. Gage. |
| Wire, brass | Pound. Gage, old or new. |
| Wire, copper | Pound. Gage. |
| Wire rope | Pound. Size. |
| Wire netting | Square foot. |
| Wood rod | Foot. Size. |
| Wood rod couplings | Each or pair. Size. |
| Wood slabs | Cord. |
| Y. Yarn for packing | Pound. |
| Z. Zinc | Pound. |

## SECTION IV

# QUANTITY AND QUALITY CONTROL

## SHOP AND PRODUCTION ORDERS

**187. Origin and general classification of orders.** The customer's order must go through a process of subdivision before it is in shape to start activities in the shop. The customer's order is usually translated into shop terms and written on shop forms, which are known as shop orders. These may or may not be collective orders; in other words, one shop order may or may not contain a variety of machines and parts. Whichever is the case, the shop order must be still further subdivided into orders for individual parts, sometimes known as production orders. There may be quite a variety of these for one part; for example, foundry, pattern, machine-shop order, and so on. All of these production orders must be related and referred to the original shop order by means of some system of numbering, such as described in paragraph (190).

**188. The shop order.** To what extent copies of the shop order may be used in various shop departments depends entirely upon the nature of the product manufactured. For example, in the case of complicated machinery, the shop order will be of service simply to notify the production office that a machine of a certain type is required, and sub-orders, or production orders, would then have to be issued by the shop office for the various departments. However, if the article manufactured is simple, consisting of but one or two pieces, manifold copies of the shop order may serve as production orders to the various departments. In general it is good policy to use the shop order manifold copies as much as possible. Shipping bills and invoices, as well as priced copies for record files, are simply copies made out at the same time that the original order is entered. Where the ordinary typewriter is not powerful enough to manifold the required number of copies, a billing machine can be used, which will make from twelve to fourteen legible copies of the original order. (See Fig. 98.)

**189. Shop orders** are often made on letter size plain sheets punched for file boards. The departments to which these are issued are denoted upon these copies by means of rubber stamps. Sometimes special printed forms are used, containing spaces for such notations as are necessary during the handling of the work in the particular department. For example the shop copy of the order may be provided with rulings for tracing the work through the shop, keeping a record of cost, and so on. Sometimes shop orders are in card form for indexing in desk files. This is convenient for quick reference, but will not work well with long, collective orders.

Fig. 99 shows how a collective shop order may be subdivided so that individual items only are called for on card forms. In a case of this kind it is not necessary to reproduce each item on a card;

for example, the material comprising pipe fittings, which would be kept in the stock room and upon which work would not have to be

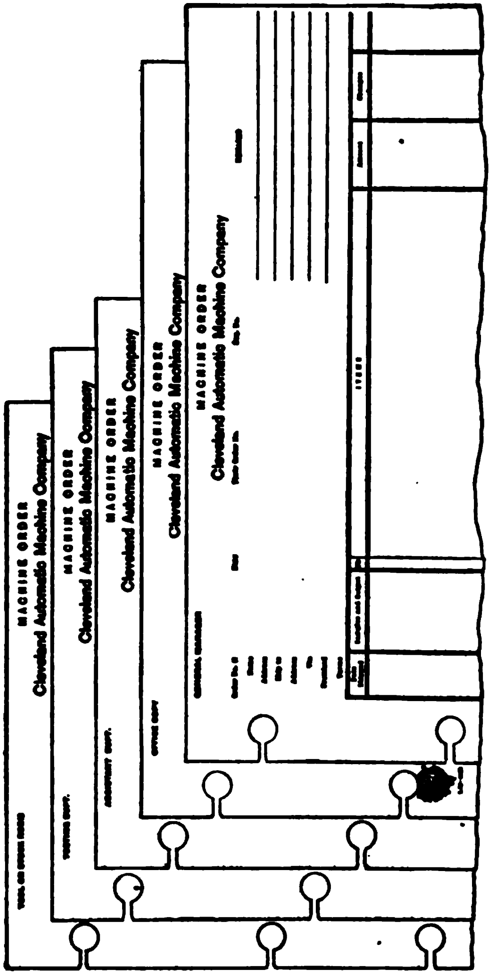



FIG. 98.—Manifold shop orders.

done, would not be carded, but requisitioned direct from the col-
-tive order.

Where board files of the Shannon type are used, the proper loca-

tion of the punch holes is very important. Customarily this is at the top of the sheet, near the title. A far better scheme is to put it at the bottom of the sheet and file the sheet upside down, in which case titles may be more readily inspected.

```
Date- 6-12-14                              Order No. 18347

Ship to-   Great Western Construction Co.
               Omaha Denver.
                                           Wanted. 6-12-14
Via Freight.

a- 3- Fig. 622 Size 6"  Brass Fitted.

b- 1- Fig. 1831  With bracket for motor attachment .

c- 2- Fig. 794, Size 8 x 10.   Regular except geared 6 to 1.

d- 1- Extra rawhide driving pinion for above.

e- 6-Fig. 83.  4 x 10, Brass Lined.  Galvanized fittings.
     4" suction, 3" discharge.

f- 1-Fig. 43.  Size 4".  Regular construction.

g- 1- Fig. 67.  With motor drive.

h- 50- 3" glav. elbows.

i- 50  4"   "     "

j- 20  3x3x4 teels.  galvanized.

k- 1200 ft of 3" galvanized pipe, with cpl'gs.
```

```
6-12-14                  18347-c.

2-Fig. 794,   8 x 10.

    Geared 6 to 1.

 See drawing list 4-96.

 Wanted 6-12-14.
```

FIG. 99.—Collective shop order and individual shop cards.

**190. Shop-order numbering.** Numbering of shop orders is for the purpose of indexing and locating. In general the simpler the system of numbering adopted, the better. Straight consecutive numbering has the disadvantage that in time the numbers will reach such size as to be confusing to those who have to handle them. It is not at all uncommon for those who handle orders in the shop to memorize the various numbers and to refer to them in that way.

If the number is very large this is a matter of some difficulty. The size may be kept down by putting them back to zero periodically, the difficulty to be anticipated when this is done being the confusion of one order with another of a previous period. This is avoided by prefixing a letter, such as *A*, *B*, *C*, before the number, and changing this letter with each period. One advantage of this system is that it immediately indicates all orders in the shop belonging to the

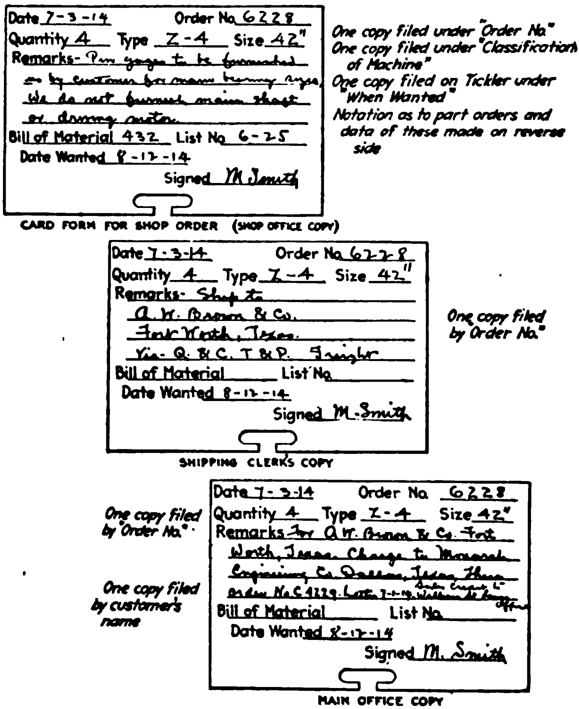



FIG. 100.—Handling and filing the individual shop orders.

previous period, which should have particular attention paid to cleaning them up.

Where sales statistics are used it is sometimes the practice to arrange the number system in conformity with the classification of statistics; for example, prefix or affix letters indicating whether the nature of the order is a new order or a repair, a domestic or foreign, a regular or a special construction.

**71. Filing shop orders.** Shop orders in active use are usually according to the order number. Additional cross-indexing to

the type and size of machine is desirable, since the system of filing by order number gives no clue as to the quantities of each type and size of machine which are on order and which is an important thing to know. Where the *card form* of shop order is used, it is a simple matter to make two or more copies of the card at one writing, file one according to order number, and the other according to machine type and size, Fig. 100. Where the *sheet form* of shop order is used, it will be found more convenient to make the cross-entry of the machine type and size in a loose-leaf ledger particularly adapted for that purpose, since each entry will require but one line, whereas if a copy of the shop order was used for that purpose it would require a whole sheet. It is hardly necessary to say that the record of orders in the loose-leaf ledger must be kept up-to-date by crossing off those which are shipped and cancelled, as otherwise it will be misleading instead of value.

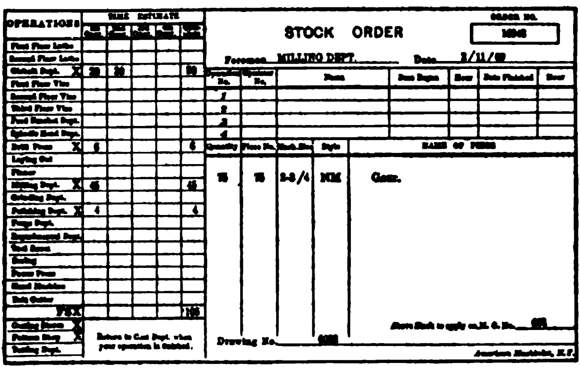



FIG. 101.—A stock order and routing form combined.

**192. Stock and special orders for complete machines.** In connection with shop orders the distinction must be noted between stock orders for parts and stock orders for complete machines. There is not always a definite relation between the number of machines ordered for stock and the number of parts on the same machines which are manufactured or put through. In the latter case the quantities are determined more from the point of view of a suitable-sized or economical lot for machining. In some cases complete machines are not built for stock at all, which does not necessarily signify that they are put through one at a time; but that they are not manufactured until a sufficient number of orders has been received to make the entire lot available for immediate shipment when produced, Fig. 101.

**193.** Good practice in shop orders avoids the combination order, in which several different types of machines are specified under one number. A good rule is to allow but one type of machine to an

order number. To insure that the various parts of a collective order from a customer which are required for shipment at the same time are not overlooked when this scheme is adopted, reference letters are used as shown in Fig. 99. Thus an order slip marked 1758*d* (*a* to *e*) would automatically call attention to orders 1758*a*, 1758*b*, 1758*c* and 1758*e* which are required on the same shipment.

**194. Numbering of stock orders.** The numbering of stock orders may or may not be the same as that used for the regular shop orders. It is sometimes good policy to omit customers' names from orders altogether, in which case there is no means of telling whether the order is for stock or on an order of shipment. This prevents stock orders being overlooked or set aside as of minor importance, which is sometimes found to be the case. Where this system is used the customer's name, date of order, and the customer's order number, are recorded in what is known as the order-record book, consisting of a consecutive record of serial numbers, opposite which the entries described above are made as fast as the numbers are reached. This system is particularly well adapted to cases where it is desired to prevent a list of customers from being made by employees. Where it is necessary to distinguish stock orders from special orders in the shop, as well as the office, this may be done by using a different series of numbers and prefixing or affixing a letter to indicate stock.

**195. In the case of special orders** and where the rule is in force to enter but one type and size of machine to an order, it is a step toward simplification to give the machines which are shipped numbers corresponding to the shop-order numbers. In case there are a quantity of similar machines on an order, they may be distinguished by stamping additional numbers or letters affixed to the shop-order number. The advantage of this plan is that when the customers write in regarding repairs for a certain machine number, the original shop order can be at once pulled from the file. This scheme cannot be adopted where the shop-order numbers are set back to zero periodically, unless the periods are for long terms, as, for example, 10 years, in which case there would be little liability to confuse the machines on two orders of a similar number.

**196. Blind numbers.** To make sure of identification of machines which are sold to customers, even in case the numbers are changed or defaced, blind numbers are sometimes used which are placed in a position known only to the manufacturer of the machine, and are covered with paint or filler. The location is usually an inconspicuous one, and one in which little liability to defacement of the number is probable.

**197. Bill of material used as a shop order.** In the cases of both stock and special shop orders, it is often good practice to use the bill of material as a shop order. On standard machines these bills of material may be furnished in advance and provided with spaces for customer's name, address, and quantity of machines ordered. Sometimes the same bills of material are used over and over again, being returned to the office after shipment and having new entries made upon them in the form of pasted slips containing information regarding the new orders.

**198. Production orders.** Production orders for the various parts of manufactured machines are necessary where the product is at all

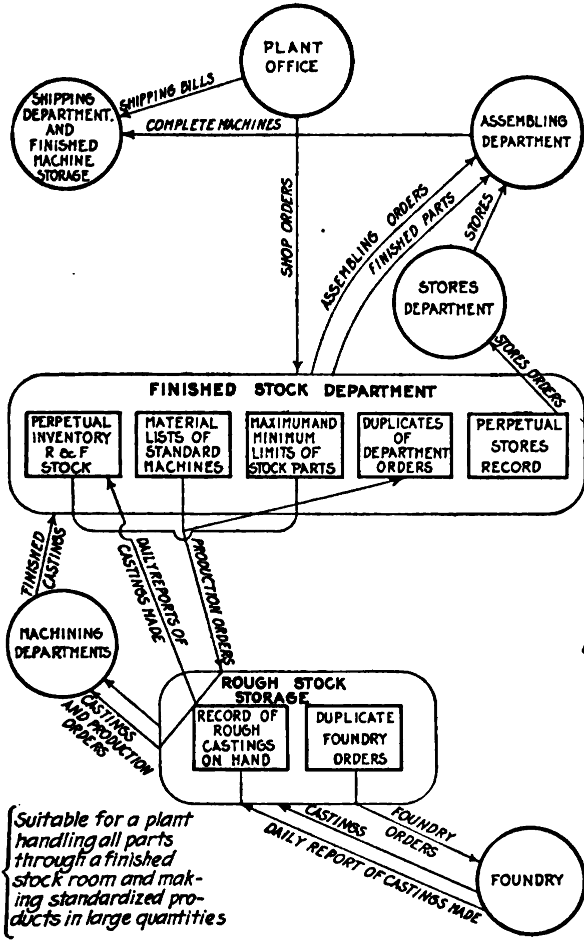



FIG. 102.—Graphical outline of production order system.

complicated. In the small shop and where little variety exists, they are sometimes done without. They are also quite necessary when work is to be traced through the shop and when it is to be dispatched

according to time schedules. Production orders also assist in the obtainment of accurate costs. They are usually of card form, or small slips, 3 × 5 inches.

**199. Collective production orders** are occasionally used, in which more than one item is entered on a production order. For example,

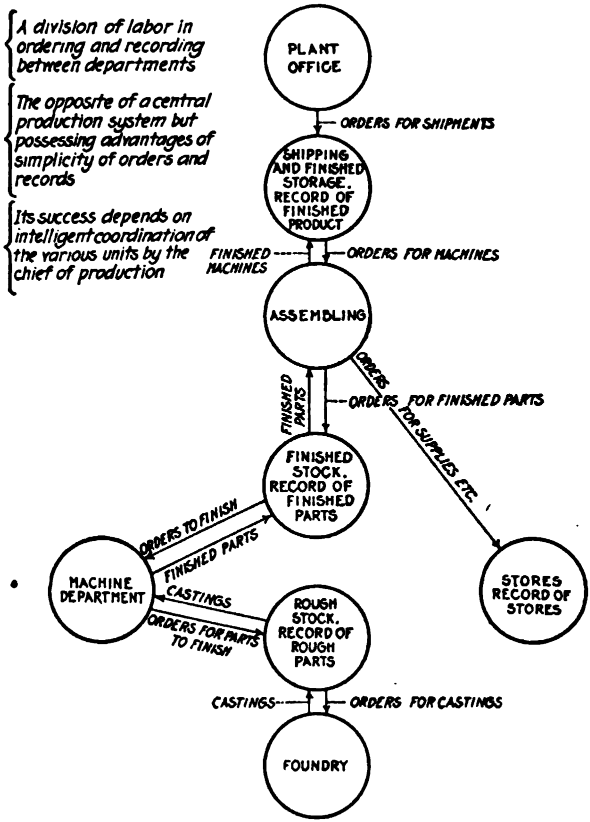



FIG. 103.—Graphical outline of inter-department production orders.

all of the castings required on a special order might be ordered in the foundry on one sheet, which in this case would be a collective foundry production-order.

**200. Inter-departmental production orders** are illustrated in Fig. which shows the procedure when one department requisitions material from another. Where this practice is followed orders

are often written in book form, each department having a book for orders issued and a book for orders received. A central clearing house for orders is formed in the shop office, where interchange of entries is made from book to book. The disadvantage of interdepartment production orders lies in the lack of centralized control, while its advantage lies in its simplicity.

**201. Machine-department production orders.** In the machine department conditions determine entirely the elaborateness of the system of production orders used, which may vary from none at all to a complete operation order system in which individual slips are issued for each operation. (See Fig. 104.) Where men do the same work day after day there is no necessity for issuing repeated orders to them. Their daily time cards, in connection with the inspector's check of

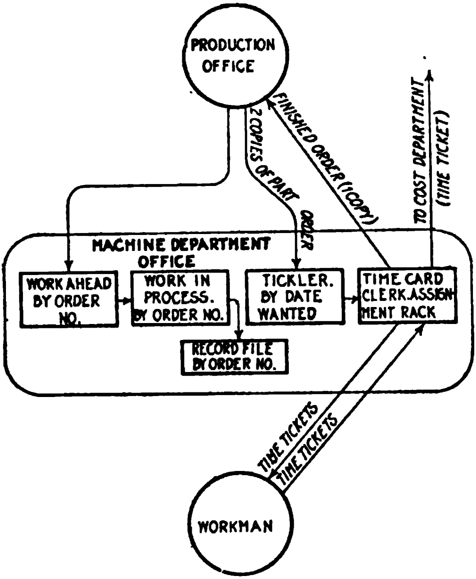
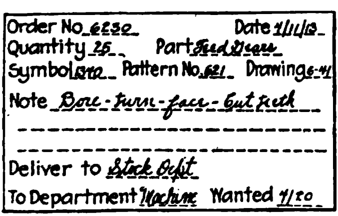
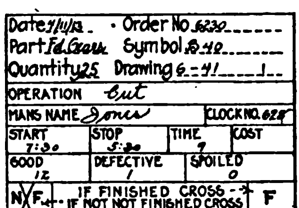



Fig. 104.—Graphical outline of machine department production orders.




PART ORDER

Fig. 105.




TIME TICKET

Fig. 106.

quantity, is sufficient for a record. This condition is also met in a more formal manner by the use of standing order numbers to describe this work for the purpose of accounting.

**202. Part orders** as distinguished from operation orders, are usually retained at the foreman's desk, time cards being made out from the card order by a department clerk or timekeeper, and issued to the individual workmen as required, Figs. 105 and 106. Occasionally job cards are used, as illustrated in Fig. 168. Where part orders are issued two copies are generally sent to a department, one being filed by order number for record purposes, the other for use in the active tickler. When the order is completed one copy is filed for reference by order number, and the other is sent back to the production office marked "completed." Sometimes the same part receives successive operations in various departments. Under these conditions it is usual to issue a part order for each department, except where job cards are used, which follow the work from one department to another.

**203. Operation orders** are made out in cases where dispatching systems are in use, and where it is required to obtain a very close and detailed cost. A separate order slip covers each operation on the part in question, usually being made out in the central production office and filed in the work ahead spaces allotted to the various machines in the department concerned.

**204. Practice varies** in different plants with regard to the question of holding back production orders until the material is available. In some cases production orders are issued to the various departments as fast as the shop orders are received, which is possibly a good way to avoid responsibility and put it up to the next fellow. The first method is by far the best, since the receipt of an order is then positive indication that the material is ready to be worked upon.

**205. Division of production orders.** Production orders take various forms depending upon the purposes for which they are used. Different requirements must be met in the pattern shops, foundry, machine shop, and upon the assembling floor. Definite procedure with regard to any one of these forms must indicate by whom the order is issued, its form, how filed, how handled in actual use, how recorded after its functions are completed.

**206. Pattern orders** are usually issued by the drafting department for new patterns and for changes of patterns. Pattern orders should contain information as to the pattern number and the corresponding drawing. A 3 × 5-inch card or slip is usually sufficient for this purpose. A larger size may be used where data are recorded on the back of the slip. Pattern orders often contain a space for a record of the weight of the casting, the order being returned to the production office when completed, and finally sent to the cost office where this weight is recorded for cost purposes. In order that the records in the pattern loft be kept up to date, it is a good plan to attach the pattern order to a new pattern and require it to be sent to the pattern loft where the new record is made before allowing the pattern to go to the foundry.

**New pattern orders** may be completely identified by the pat- n number and date, since a pattern is made but once. Pattern ge orders are often distinguished from orders for new pat- by a different color of slip. This may be numbered in

various ways according to conditions which are to be met. In a plant, for example, where pattern changes are frequently made to meet special order requirements, the change slip should refer to the special order number so that the cost of making the change in patterns can be charged against that order.

**207. The necessity for repairs** to patterns may become evident either in the foundry from actual inspection of the patterns or in the machine shop, due to the distorted nature of the castings. The issue of repair orders for patterns is usually vested in the foundry management to whose interest it is to keep to a minimum the number of castings rejected by the machine shop.

Where individual costs are kept on pattern repairs, the order must be given either a serial number or a number corresponding to the

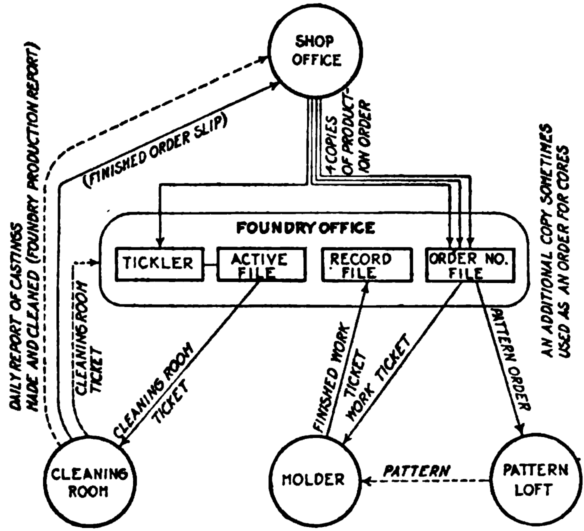



FIG. 107.—Graphical outline of foundry production-order system.

pattern number and date. Where pattern repairs are grouped as a subdivision of expense, a standing order may be used to cover this point.

**208. Other pattern records and reports.** It is customary to maintain in the pattern loft a record of patterns out of storage. Such patterns may be in the foundry of the home plant or may have been sent to another plant as is frequently the case with patterns for brass, bronze and steel castings. There is also of course the record of pattern numbers described in (59).

**209. Foundry orders.** Foundry orders are usually issued from the shop production office, from the bill of material, drawing or some other source of information. In form, foundry orders may

either be individual order slips or collective orders, which are sometimes used when the practice is to issue work tickets to the molders which are made out in the foundry production office. The necessity for this is determined by the capacity of the shop production office with regard to handling the number of individual tickets necessary, which depends somewhat upon the class of work, Fig. 107.

**210. Individual foundry order slips** should contain information as to piece name, pattern number, quantity wanted and date wanted, as well as a reference to the original shop order from which they are derived, which may be made a part of the system of numbering employed. Foundry tickets are usually small slips, 3 × 5 inches. As many copies of these are made out at one writing as are required by the routine employed in the foundry production office.

**211. Foundry-production orders** or a copy of them are frequently used as notification to the pattern office that a pattern is wanted. In this connection, it is possible to arrange a pattern transportation system so that the required patterns are delivered to the molders' floor prior to being required for use. A copy of the foundry-production order may also be used in the pattern loft as a record of patterns out of storage, being placed in a card holder at the location of the pattern, showing the location of a pattern in active use, and being destroyed when the pattern is returned. Other uses of foundry-production order copies are; to form a production tickler for the foundry office, work ticket for the molder, cleaning room ticket and as a basis for foundry-production records. The return of a copy of the foundry-production order to the shop office constitutes a notification of completion of the order, Fig. 108.

| DATE WANTED | DATE ISSUED | PATTERN NO. | ORDER NO. |
|---|---|---|---|
| QUANTITY | PART | | |
| MOLDER NO. | NAME | | |
| STARTED | COMPLETED | TOTAL GOOD | TOTAL BAD |
| (SPACES FOR SPIRAL NOTATIONS OR INSTRUCTIONS) | | | |
| | | | |
| FOUNDRY PRODUCTION ORDER | | | |

Fig. 108.

**212. Foundry-production reports.** A daily report of castings made in the foundry is quite necessary, so that the machine-shop production office may check up the condition of its orders. The return of the foundry-production order slip, while indicating the completion of an order, does not show the partial deliveries which may be made day by day, as does the daily record of castings made. Another use of this report is for obtaining an accurate cost of foundry operation, which requires that the output be definitely known. It is best to make this report at the cleaning room, so that the number of defective castings may be deducted from the record. It is sometimes the practice to have a weighmaster in the machine department to receive and check all castings delivered from the foundry. A daily record of castings made should contain the following information: Order number, weight, pattern number, name of part, quantity, and for what department. Where foundry costs are kept

by classes of castings, individual weights need not be given on this report.

**213. In the foundry-production office** work is planned by the use of various files, containing copies of the foundry-production orders. One of these is a foundry-production tickler containing copies of these slips arranged in order of date wanted, and is useful in laying out work. Another file contains a set of copies arranged by order numbers, since all references from the machine shop and other depart-

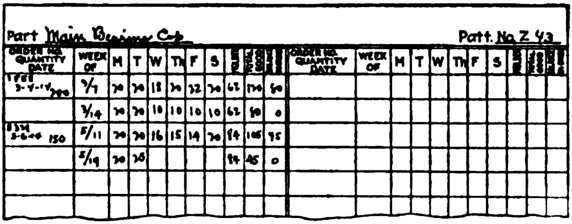



Fig. 109.—Foundry production record.

ments will be made in this manner. An active file may contain slips which were filed in the production tickler prior to being worked upon, and in which all work in process is recorded. A record file, in which the finished slips are arranged according to order numbers, permits of information being given regarding the date that any casting has been made, when its order number is known. The use of duplicate slips in a foundry-production system is illustrated in Fig. 107.

**214. Use of colors to indicate the age of orders.** The age of an order may be told by the color of the order slip, provided these colors are changed periodically. It is usually customary to change the colors once a month when this system is used. The number of colors necessary is determined by the maximum duration of an order in the shop. Thus, if colors were changed every month, six colors would be sufficient, providing all orders were cleaned up within six months.

**215. Another use of distinctive colors is to indicate the urgency of orders.** This scheme is used when no definite planning of work is attempted. A number of colors or a color schedule might represent the relative urgency of orders divided into several broad classes. For example: Red—breakdown or express orders; blue—promised order of urgency; buff—regular procedure; white—stock order. A difficulty experienced when this system is used is a tendency to put everything through under "urgent" orders, especially when a shop is crowded with work.

**216. Numbering production orders.** It is necessary to number production order slips so that they will refer to the shop order from which they originate. An exception may be made in the case of stock production orders for parts which are not related to complete machines. Where production orders are used but once, the date

of issue in connection with the shop-order number and symbol of part will usually be a sufficient identification. If serial numbers are given to the production orders, it necessitates cross-reference to an index to identify them.

**217. Standing production orders.** Orders are sometimes issued covering a given rate of production. In other words, so many pieces are to be made per week or month. This practice saves considerable clerical work and is possible where a somewhat uniform rate of output is maintained. One advantage of this system is the ease of planning. For example, if the preceding year's sales' analysis indicates that 12,000 pieces will be required within the next six months, a standing order may be issued for a rate of production of 2000 pieces per month, and any falling off from the anticipated amount will be easily detected. A form used in the foundry production office for this purpose is shown in Fig. 109. A card is made out for each article and spaces are provided to check up the actual daily production against the estimated or planned rate of production. Losses through defectives may be made up by increasing the rate of production during a following period, after the percentage of loss is well established. In one-product shops, production orders are sometimes dispensed with altogether, except in such cases where definite lots are to be machined. Where the operation is practically continuous, there is no necessity for production orders, since the time card and inspector's count are sufficient to keep a record of output properly.

A standard lot quantity enables the repeated use of the same production order, which is then in printed form. Dates or affix letters are changed in order to identify the order. The Bullard Machine Tool Co. uses the same production order four times, four spaces being provided for identification dates, the lot number remaining standard in each case.

**218. Handling split lots.** Oftentimes it becomes necessary to change the quantity in a lot being machined, or to subdivide it into two or more parts, one of which may be laid aside for a time while the other is hurried through. It is necessary to be careful when this is done to distinguish the numbers of the split lots suitably, so that there will be no possibility of confusion. The order number applied to a split lot ticket should in its nature indicate that the lot is split. It should also refer to the original order number covering the whole lot. The greatest difficulty in connection with split lots is encountered in the cost department where any indefiniteness regarding the quantity of pieces worked upon will result in inaccurate costs. For this reason, the date of subdivision of the split should be distinctly marked upon the order, both the original production order for the entire lot and the production order for the smaller quantity.

**219. Sometimes pieces are machined for stock** up to a certain point, depending upon the condition of live orders, and are then put through the rest of the way on the special order numbers. This is also true where certain parts are standard up to a certain point of construction and then become special. These cases are also covered as indicated for split lots. Where the numerical system of numbering production orders is in vogue, necessitating a reference

to an order number record, new orders are sometimes issued for split lots referring to original order numbers.

**220. Material shortages** are sometimes of small importance where large lots are manufactured for stock and when a difference of a few pieces in several thousand is quite negligible. On work where material shortage is likely to cause delay or an increased expense necessitated by bringing through the small number of pieces required to make up the shortage, it is good practice to start the original lots large enough to allow for all probable losses which may occur. Even on special machined parts which are not likely to be used again, the completion of one or two extra pieces, is, as a rule, much less expensive than to bring through this same small quantity by itself to make up a shortage.

**221. Assembling orders.** Two general plans are in use in regard to handling assembling orders. In the first these are issued by the

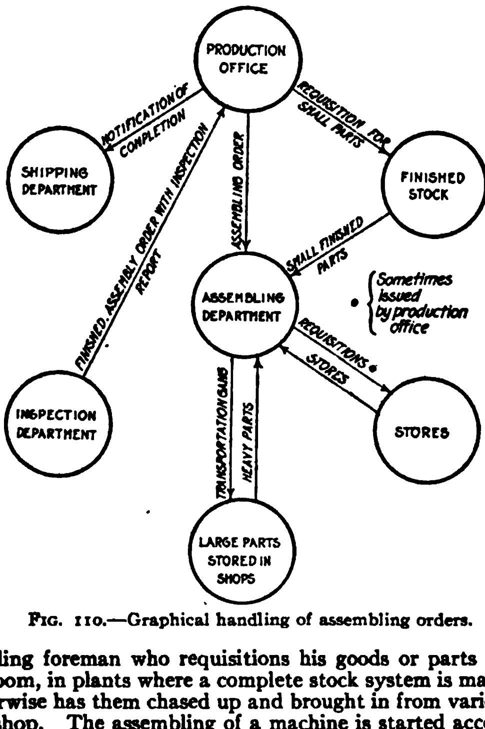



FIG. 110.—Graphical handling of assembling orders.

assembling foreman who requisitions his goods or parts from the stock room, in plants where a complete stock system is maintained, or otherwise has them chased up and brought in from various parts of the shop. The assembling of a machine is started according to his judgment and the condition of his floor. Another plan is to hold the assembling orders in the production office until sufficient parts

are ready and then have them delivered to the assembling department at a scheduled date. Such a system is only possible where tracing and planning is done. (See Fig. 110.) Assembling orders are generally a copy of the shop order in card or sheet form, see (189).

**222. Unit assembling orders** are similar to part orders except that they call for a unit assembly; this is to be delivered to finished stock. Shop orders cannot be used for this purpose. Unit assembling orders may sometimes be combined with the inspection report in the form of a tag to be attached to the unit assembly after inspection.

**223. Order system for small plant.** Before planning or installing any system of orders it is well to consider what purposes orders are intended to fulfill. They may be said to be the conveyance of exact information of what is required to be done, and the furnishing of a key or symbol by which to charge time and obtain costs. Another purpose for which production orders are used is to show the state of the order in the shop especially where planning or dispatching systems are used. The elaborateness of the order system required will entirely depend upon these conditions. It is quite desirable for the small shop to maintain a definite system of production orders, especially if growth of the business is anticipated, since it is much easier to start an order system in a small shop, than it is to install one in a large shop. A simple and inexpensive system of the nature of part production-orders may be established, and when time and conditions require it may be easily elaborated into an operation order system without radical changes.

**224. The rule of operation sequence.** (E. H. Schell in American Machinist, vol. 39, p. 307.) It is evident that in the assignment of operations to any given part, it is imperative that, should the productive capacity of the machines fluctuate, the variation should be in a decreasing scale as the operations proceed. This rule applies only to parts in which there are no abrupt changes in the capacity of the machines. For example, when it is found necessary to pass from one unit of high daily output to one of low production, temporary storage may be made use of and the high-duty machine allowed to complete a continuous run, the next operator drawing upon the stored reserve.

If the situation is reversed, and low production precedes a possible high daily output, the high-duty machine may be utilized profitably for other purposes over a certain interval, and operate upon the work at hand after a sufficient quantity of it has accumulated. The following illustration will perhaps best show the great effects which individual conditions have upon the development of an efficient production chart:

Attention was called to a certain machine shop whose floors were crowded with a certain cylinder casting in various stages. While investigating the cause, a production chart was made. The number of cylinders in reserve between each operation was next obtained and indicated by dotted lines. The startling way in which this line lagged behind the production curve showed at once that the great inequalities in the machine capacities, as well as the arrangement of the operations were, in large measure, responsible for the congestion.

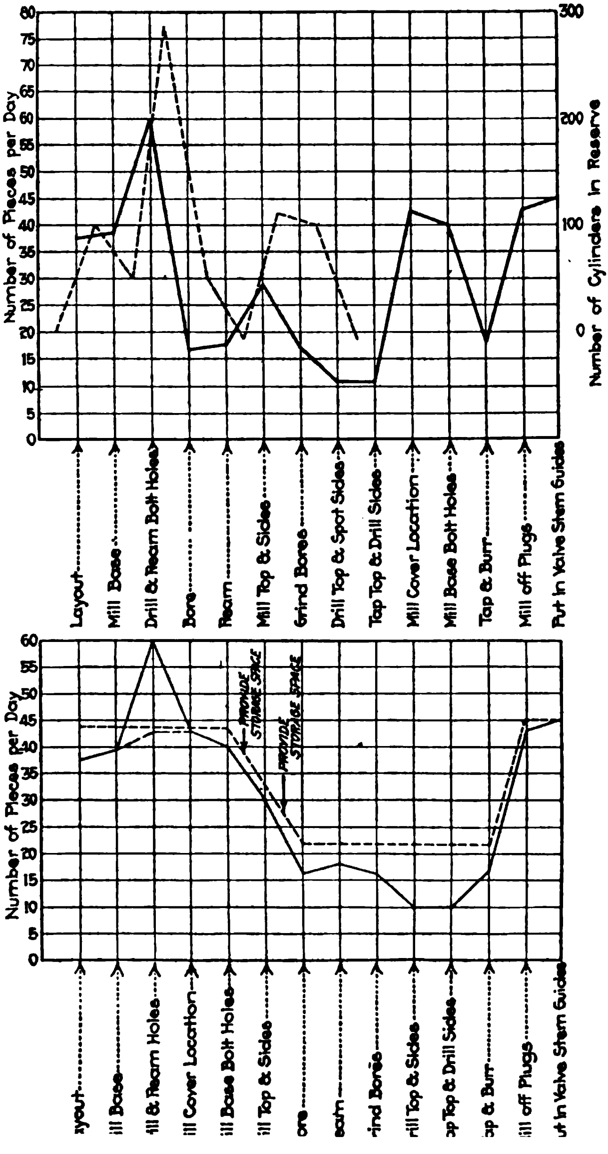



FIG. 111.—Production charts.

As is the case in all revisions of production charts, the possibility of altering the sequence of operations was first considered with the aim of developing as nearly as possible, a series of level or downsloping portions connected by steeper slopes where the great variation in daily outputs was unavoidable. The revised chart is shown at the left of Fig. 111.

The dotted line beneath the peak of the third operation indicates that the multiple drill which is here employed may be operated only enough each day to complete the daily product required by the next machine. Between the fifth and sixth and the seventh and eighth operations, storage space was suggested, thus allowing the highly productive factors to complete the lot at once and become otherwise available. The last two operators, having large daily output, the variation is sufficient to allow them to spend a portion of each day upon other work.

A study of the various jigs, fixtures, machine tools and methods of operation indicated that a production line as shown by dashes in Fig. 111 was not unattainable, and in this, the entire problem was analyzed and placed in clear, understandable form, the difficulties made evident, the delays and congestions explained, and the remedies suggested.

## STOCK AND STORES METHODS

**225. An availability index.** Where it is customary to carry finished machines in stock an availability index is convenient to show the number of these which are on hand above orders. The records and reports necessary to maintain an index of this kind are three, as follows: (*a*) A daily report of *orders received*. (*b*) A daily

| Fig | | | Type | | | Size | | | |
|---|---|---|---|---|---|---|---|---|---|
| ORDERS | | | REC'D FINISHED | | SHIPMENTS | | | | |
| Date | Quantity | Order No. | Date | Quantity Rec'd | Date | Quantity | Order No. | Bal. on Hand | Available |
| 3/1/12 | 100 | ~~64528~~ | | | | | | 1200 | 1100 |
| | | | 3/7/12 | 200 | | | | 1400 | 1300 |
| 3/11/12 | 450 | ~~85264~~ | | | | | | 1400 | 850 |
| 3/12/12 | 200 | 95783 | | | | | | 1400 | 650 |
| | | | | | 3/14/12 | 100 | 64528 | 1300 | 650 |
| | | | | | 3/16/12 | 450 | 85264 | 850 | 650 |
| 3/20/12 | 900 | 104030 | | | | | | 850 | 250 |
| | | | | | | | | | |
| | | | | | | | | | |

Balance forward from old card

Shows that the condition is 250 behind orders although 850 finished machines on hand

FIG. 112.—An availability index.

report of *finished product by order numbers*. (*c*) A daily report of *shipments by order number*. The form of card used in this index is shown in Fig. 112. The first two items, (*a*) and (*b*), affect the net available column, orders received being deducted and finished [illegible] orders being added. The process of making entries and [illegible]t on the balance may be seen from study of the figure. [illegible] availability index forms a very logical means of con- [illegible] orders in the factory. Maximum and minimum [illegible] be placed upon each card to indicate when orders

should be issued and also in what quantities. An availability index may be extended also to the various parts comprising the machine, this is not customarily done on account of the number of entries involved, except in the case of purchase stores.

**227. Physical arrangement of stock department.** The methods of ordering, cost keeping and inspecting in any plant, largely depend upon the physical arrangement of the rough and finished stock department. The closest accounting is possible when all goods pass through the stock department and this is also conducive to the most accurate record of production and state of orders. This is possible however only in the most favored plants. In the average machine shop there is usually a great range in the sizes of parts of machines, some of which are too large to store other than in the departments where they are machined. There is also a distinction in stock methods between the number of times a given piece may pass through the stock room, which may be simply as an entirely rough or entirely finished part or may be at the termination of each successive operation. The latter is possible only where the lightness of the material handled makes transportation an unimportant feature.

**228. Stock and stores orders.** These are usually small slips issued by designated officials calling for the items to be delivered,

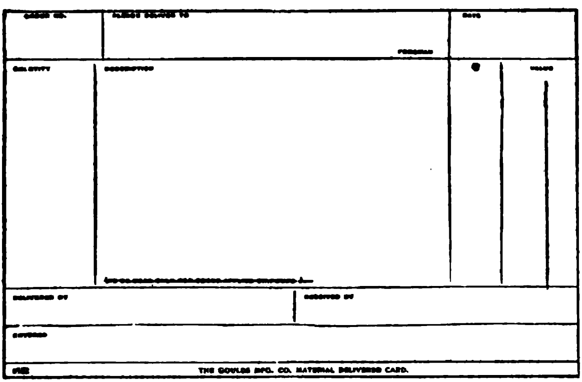


FIG. 113.—A common form of stock and stores order.

and are presented at the stock or stores-room window by the one going after them. Sometimes the stock and stores departments take care of the delivery of goods called for on orders sent them. When a general transportation system is in use this is utilized for delivery of stores and stock orders, and for the delivery of the goods as well. A common form of store and stock order is shown in Fig. 113. The distinction between stock and stores orders is made by the color of the ticket, one being white, and the other being red.

**229. Where a cost-of-order system is in use,** stock and stores orders are given order numbers which will relate them to the shop order on which a cost is to be kept. Where the attempt is not so much a cost-of-order system as a close analysis of expense, the stores tickets when filled are sent to the accounting department and are subdivided into groups after being priced, in order to arrive at figures representing the consumption of these commodities during different periods of time. To make this possible, one kind of commodity only should be ordered on one order ticket.

**230. Location of stock departments.** The rough and finished stock departments are often in separate locations arranged conveniently to the departments to which they contribute. This places the natural location of the rough-stock department near the foundry while the finished-stock department must be easily accessible by the machining departments and the assembling department. Subsidiary stock rooms are sometimes located in the various departments, where the plant is large enough and the necessity for reducing transportation makes it desirable. Often the production system centers about the rough- and finished-stock departments. An illustration of this is shown in Fig. 102. In this case, orders originate in the stock rooms, foundry orders being issued from the rough-stock room, while finishing orders are issued from the finished-stock room.

**231. Stock symbols.** The ideal numbering or symboling system would be one in which the symbol itself made evident (*a*) the drawing location; (*b*) pattern location; (*c*) stock bin location; and (*e*) the nature of the part or on what machine it was used. Unfortunately in most shops conditions do not permit of such a simple method of numbering, this is largely due to the fact that the various numbers used for these purposes are outgrowths of conditions which existed at different times. Quite frequently the pattern number is used as a stock symbol, but if the stock bins are numbered to conform with the pattern number a cross-index for bin location will be necessary, except in a case where the pattern numbers are arranged according to pattern location and the bins for the storage of stock follow the same arrangement. This matter is worthy of some thought when starting a new line of manufacture since simplification of location of these things is a long step toward efficient handling.

**232. Bin numbering.** It is customary to provide each bin in a stock room with a number, for the purpose of quickly locating any part contained in stock. A cross-index is usually provided giving the bin number, and arranged or indexed according to manufactured part contained. There are a variety of methods which may be used for numbering bins. Two examples of a numerical system are given in Figs. 114 and 115.

The first provides for an indefinite expansion of sections, the second for an indefinite subdivision of bins within each section.

**233. Bin arrangement.** There are two distinct methods of arranging or grouping product parts within stock bins. One of these [illegible] distribute the parts of a given machine to various bins and bin [illegible] according to the size of part and nature of its material. A [illegible]n is to keep the parts of a given machine in one section

as far as possible. The first method permits of standardized bin construction, and therefore requires less investment in the

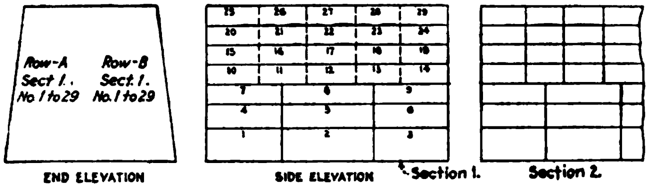



FIG. 114.—Arrangement of bin sections.

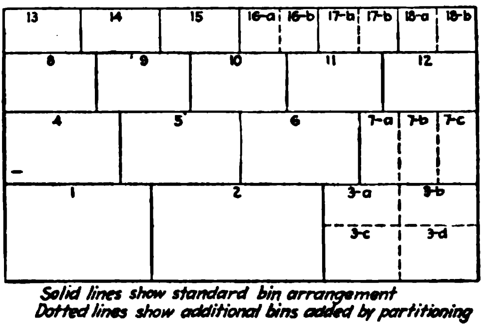



FIG. 115.—Method of numbering bins in a section.

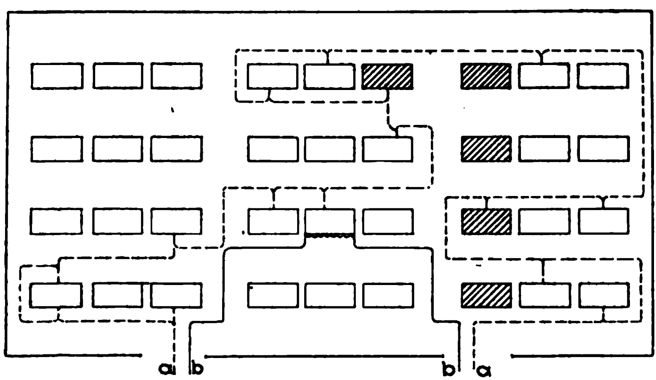


FIG. 116.—How stock arrangement affects transportation.

stock room. The second method has the advantage of reducing the transportation necessary to collect the various parts for assembly. (This is graphically shown in Fig. 116.) Sometimes

valuable material such as brass or bronze is kept in auxiliary stock departments under lock and key. Where the main stock department is inclosed this is an unnecessary precaution, especially where accurate records of the bin contents are kept.

**234. Stock system for the small plant.** The purposes of any stock system may be defined as follows: (*a*) to provide a *systematic location for parts*, (*b*) as an *aid in ordering*, locating the parts, and keeping a record of them; (*c*) *to secure the parts from loss.*

In the small plant which cannot afford the services of a stock-keeper or has not room for a suitable separation of stock from the manufacturing department, bins and shelves may be built about the wall, providing a definite location for the stock parts. In this case locked cupboards afford security for valuables, the foremen of the department having a key.

Bin records (as illustrated in Fig. 130) form the perpetual inventory, and orders are issued either from inspection of the bins or from the inventory record card.

**235. Another stock system for the small plant.** Some plants which cannot afford to maintain a store or stockkeeper exclusively for this class of work, may use a combination in which certain producing machines are located in the stock department, and are operated by the stockkeeper when he is not busy at the window. Another plan which has been followed successfully is to assign certain office hours for the store department, at which time the attendant is present, he being usually one of the office force. The hours for opening such a store department are preferably the first two in the morning, and the first one or two after lunch hour.

**236. Standard bins and other plans.** Sometimes standard bin spaces are arranged to receive tote boxes which are made in multiples of a certain sized unit for convenient storage. In this case the tote boxes have a bin location numbered upon them to insure their being returned to the proper place.

In some large and successful plants no bins are used. For example, in the stock room at the Ford plant the parts in stock are contained in wooden boxes which are piled in an orderly manner in the stock room, each box containing a certain definite quantity of pieces, usually 50, since the cars are issued to assembly in quantities of 50 at a time.

The H. H. Franklin Co. of Syracuse keep their small stock and store parts in sealed bags each of which contains a given quantity corresponding with the lot number usually worked in the plant. The bags are sealed for the purpose of making sure that the full quantity is present.

Sometimes trucks are used for storage purposes, especially those which are fitted with a removable platform which may be deposited in any location desired without tying up the usefulness of the truck itself. Where this system is used to make the most economical use of space, it is well to standardize the method of piling or loading such truck platforms. Photographs are conveniently used for this purpose (arranged as shown in Fig. 117).

Where truck storage is used the labor of loading and unloading the product pieces is greatly reduced. On the other hand more

space is usually required as the truck platforms cannot be piled readily one above the other. A good scheme is to draw or paint lines upon the shop floor indicating the extreme limits at which these portable truck platforms may be placed, as otherwise if left to the judgment of the truckman it will be found that passageways are frequently blocked.

**237. Horizontal lines are frequently painted upon** bins which contain small parts for the purpose of estimating the quantity left in the bins.

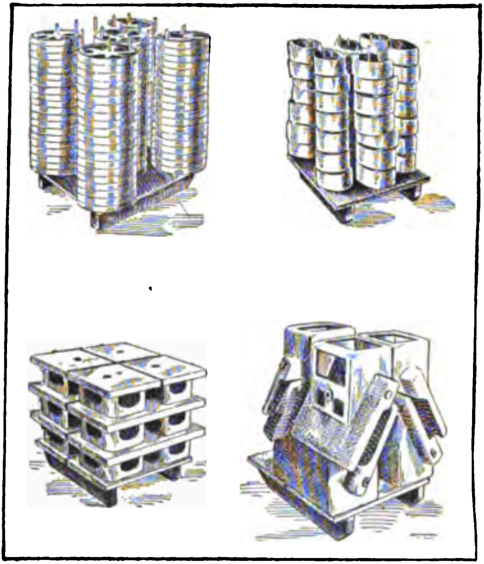


FIG. 117.—Standardization of truck loading.

*The Taylor two-bin system.* This is a system of stock-keeping originated by F. W. Taylor, in which two bins are used for each part, material being drawn from one bin while the other one is being filled. In this way accurate track may be kept of the quantities used, without the necessity of detailed accounts, by keeping track of the number of times that a bin is emptied, and knowing the quantity held when full.

**238. The Root & Van Devoort Co.'s** *standard stock spaces.* The stock is stored in spaces that are a multiple of a standard piling-board unit, 24 × 30 inches, and the floor is laid out by painting a 2-inch stripe around these multiple unit spaces. The method of piling is dependent on the shape of the material, as in some instances only one layer is placed in the space and in other cases several layers, separated by piling boards, or, again, it may be piled without any separating medium.

Small material is stored in bins. A comprehensive index of all stored material is provided. Two markers are on each bin, one of these gives the bin number and the other the name or symbol of the material in the bin. In case more material than the bin can hold is to be stored, an empty bin is chosen and properly marked, and the original bin is marked to show where the "overflow" stock is stored; the overflow material is used first.

Material to be delivered is segregated and placed on platform trucks, having two shelves. The truck may be loaded partly on one floor and finally on another before being ready for delivery.

*The next function of the stock-storage department* is the delivery of material to the proper place. It may be noted here that it is a universal rule throughout the plant that all material is delivered by the department finishing one or more operations, to the next department.

**239. Construction of bins and racks for stock purposes.** The form of racks and bins used for the storage of stock parts is a matter requiring design to suit the shape and size of the parts to be handled. A number of forms are shown in Figs. 118 to 127. Many ingenious adaptations of rack and bin forms are made for particular purposes.

FIG. 118.—Stock and stores cabinet for small parts.

Attention is called to the removable front boards shown in Fig. 123, which are taken out of the bins as the supply becomes reduced. Sectional rack construction is shown in Fig. 124 and methods of handling finished bar work in stock which reduce the liability of damage of surfaces are shown in Figs. 119, 121 and 125. Fig. 127 illustrates the method of storing product parts at the machine which may be mentioned under the classification of stock handling. It will be noted that the small parts which are put in at the top of the bins are automatically delivered at the bottom convenient to the operator's reach. Features of this kind play an important part in reducing the number of unnecessary motions.

**240. Perpetual inventory for stock parts.** Fig. 128 illustrates the simplest type of perpetual inventory in which only quantities are accounted for. A more elaborate form is shown in Fig. 129

in which the inventory card is also made a record of order numbers and is used for the purpose of originating and recording stock orders.

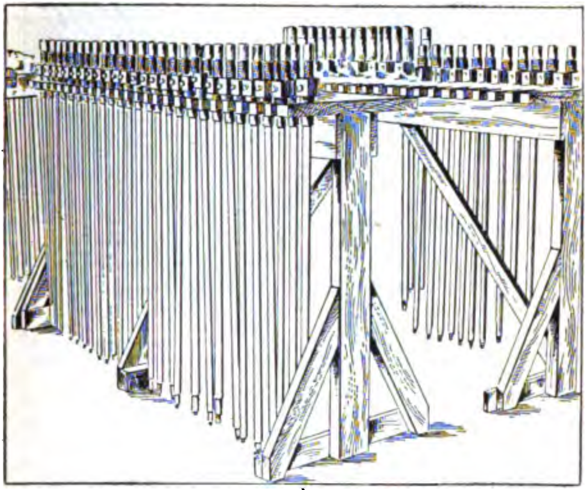


FIG. 119.—Storage of finished spindles.

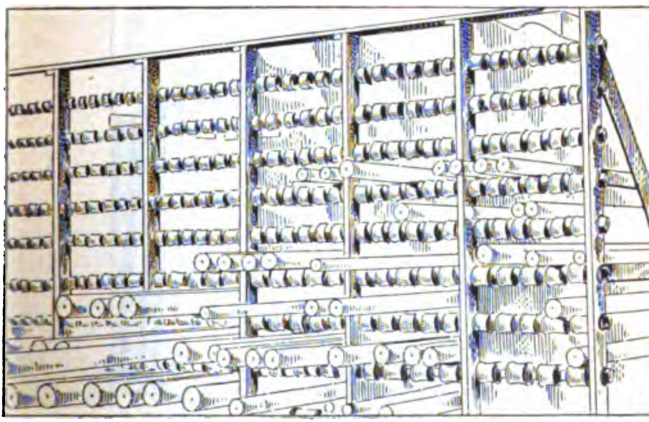


FIG. 120.—Roller racks for bar stock.

Another subdivision of perpetual inventories may be made as to the class of work handled. For example, rough and finished stock

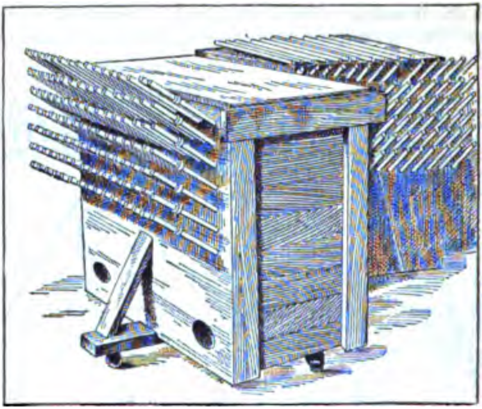


FIG. 121.—Storage of finished spindles on special truck.

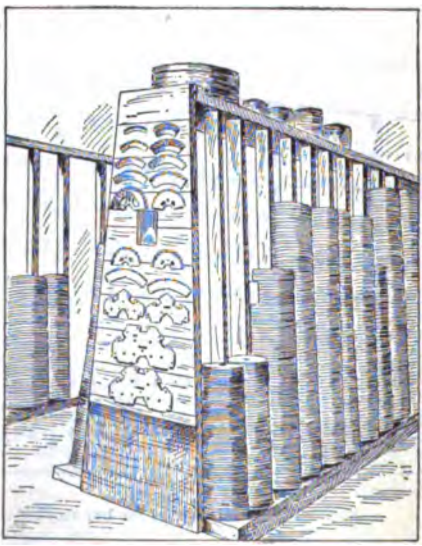


FIG. 122.—Racks for armature segments.

may be recorded on separate forms or may be combined in the same form.

*The records necessary to maintain a perpetual inventory* are as follows: (*a*) A physical inventory determining the number of pieces on hand at the start. (*b*) A record of the quantities received.

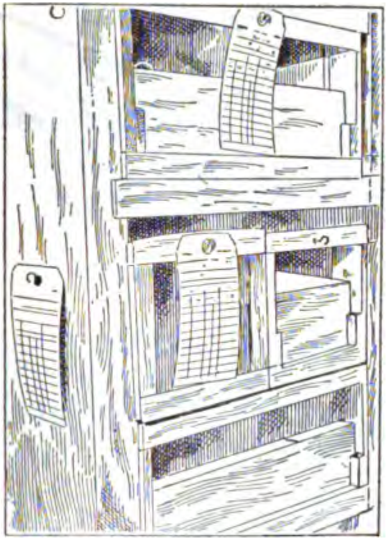


FIG. 123.—Bins with removable front boards.

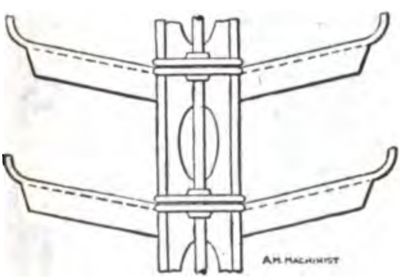



FIG. 124.—Unit rack construction.

(*c*) A record of the quantities delivered. The quantities received are added to the balance on hand, while quantities delivered are deducted.

**241. Perpetual inventory for the small plant.** A simple system of maintaining a perpetual inventory without additional clerical

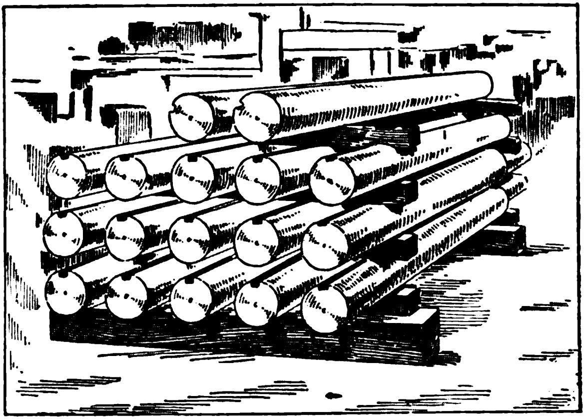


FIG. 125.—Method of piling large finished bars to prevent damage

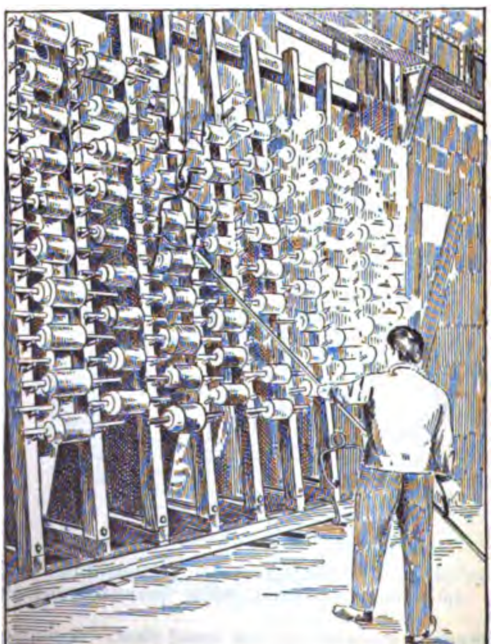


FIG. 126.—Storage racks built for rolls, armatures, etc.

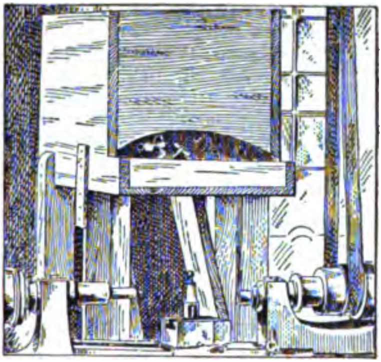


FIG. 127.—Self-feeding storage bins, located at the machine.

| Part Main Gear for B4 | | Symbol B4-24 Bin 628 | | |
|---|---|---|---|---|
| Received | | Issued | | Bal. on Hand |
| Date | Quantity | Date | Quantity | |
| 3/4/14 | (From Physical | Inventory) | | 482 |
| | | 3/5/14 | 128 | 354 |
| 3/7/14 | 50 | | | 404 |
| | | | | |
| | | | | |

FIG. 128.—Simple type of perpetual inventory record.

| Part Main Gear for B4 Symbol B4-24 | | | | | | | | Rough Bin 124 {Max. 500 Min. 150} | | | | | Fin Bin 628 {Max 300 Min. 100} | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rough | | | | | | | | Finished | | | | | | | | |
| Date | Ordered Ord.No. | Ordered Quant. | Received Ord.No. | Received Quant. | Delivered Ord.No. | Delivered Quant. | Bal. | Date | Ordered Ord.No. | Ordered Quant. | Received Ord.No. | Received Quant. | Delivered Ord.No. | Delivered Quant. | Bal. |
| 2/12/13 | | Inventory | | | | | 318 | 2/12/13 | | Inventory | | | | | 150 |
| | | | | | | | | 2/14 | | | | | B.451 | 50 | 100 |
| | | | | | | | | 2/14 | C570 | 200 | | | | | |
| 2/15 | | | | | C.570 | 200 | 118 | 2/20 | | | C.570 | 200 | | | 300 |
| 2/15 | A314 | 350 | | | | | | | | | | | | | |
| 2/17 | | | A314 | 200 | | | 318 | | | | | | | | |
| 2/21 | | | A314 | 150 | | | 468 | | | | | | | | |
| | | | | | | | | | | | | | | | |

FIG. 129.—Use of maximum and minimum limits.

labor is shown in Fig. 130. In this case, the inventory cards are located directly at the bins being in the form of tags suspended on hooks. It is simply necessary to make entries in the total column on this card when parts are placed in the bin and also when they are taken out. In the small departments such bins may be arranged around the walls of the building and be under the jurisdiction of the department foreman or someone appointed by him.

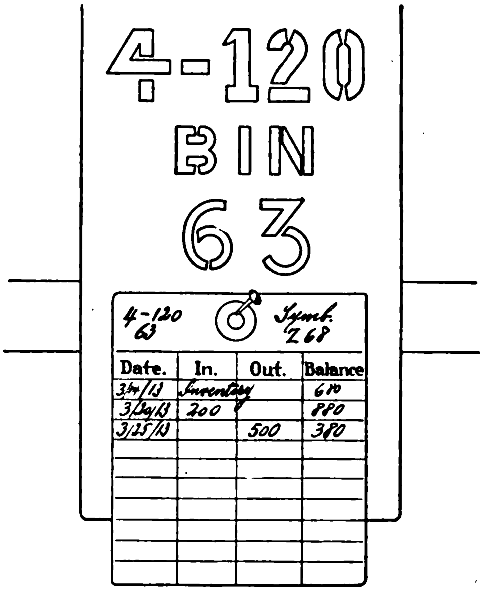



FIG. 130.—A perpetual inventory kept on the bins.

**242. Maintaining the accuracy of perpetual inventories.** Actual physical counts, from time to time, are necessary to maintain or prove the accuracy of a perpetual inventory. To do this systematically, it is well to take a certain number of items per day so that the whole inventory is covered or checked within a given period of time. For example, a check or count of six bins per day would prove the accuracy of an inventory covering 1000 bins in a period of 6 months. A schedule may be prepared showing the bin numbers which are to be checked each day and some notation required upon this schedule to indicate that this has been done.

**243. Maximum and minimum limits on stores and stock.** It is evident that when the supply of stock or stores becomes low more should be ordered, and it is equally evident that if too much is on hand the amount of money invested in stock or store

material will be excessive. To regulate this is the function of maximum and minimum limits which are assigned to various items of stock and stores by the chief of production and which are modified from time to time to suit conditions of business. When stock is reduced to an amount equal or less than the minimum limit an order is put through for an amount sufficient to bring the quantity up to the maximum limit. This is illustrated in the perpetual inventory record shown at Fig. 129 which shows how orders are placed when the minimum limit is reached.

**244. Distinction of stores from stock.** The term stock is usually applied to parts which are manufactured within the plant; that of stores being applied to purchase parts. Stores may be subdivided into direct and indirect, the former comprising such items, as pig iron, bar steel, paint, varnish, and other materials entering into the product, and the latter comprising supplies which are used in maintenance and routine, such as oils, waste and coal.

*Physical arrangement of stores.* The arrangement of stores depends upon the material handled, and the purpose for which it is intended. Foundry supplies, such as pig iron, coke and molding sand, are usually provided for in special storage bins or buildings adapted to that purpose. Bar iron and steel may or may not be contained in a general store, sometimes being kept in a bar storage department which is provided with cutting-off tools, in order that the cutting to length may be done before the material is delivered to the shop. Direct items of stores, such as bolts, nuts, studs, washers and cotters, are usually kept in the stock department for convenience in handling and delivering to the assembling department.

**245. Ways of keeping track of items of stores.** Pig iron and molding sand and other materials of this nature are usually weighed upon receipt to check up the weight given upon the invoices. These records together with a record of issue of this material to the foundry enables a perpetual record to be kept without much trouble. It must not be expected to maintain records of this bulky material to a fine point of accuracy, which would be more expensive than any value received from them. A report of consumption of pig-iron, coke, and the like, may conveniently be taken from the cupola charge record, while the sand used in the foundry is reported as so many wheelbarrows per day each wheelbarrow being estimated as containing an average quantity determined by experience. Both of these items are checked up by a physical inventory at least once a year.

**246. Method of issuing oil to employees.** It is not uncommon to see a central oil supply placed in a department from which the employees may fill their cans without restriction. This is a broad invitation to waste and excessive use, and where it is in vogue it will generally be found that the practice of cleaning the hands with machine oil is prevalent. An employer who would consider a long while before going to the expense of providing soap for employees will often unconsciously provide this more expensive material. A better scheme is to place the oil supply

under the supervision of the stockkeeper, and issue it to the employee only on orders signed by the foremen. The total oil supply per department is tabulated, and the foreman held responsible for excessive consumption.

This method entails the mechanic leaving his machine to go to the stock room, unless messenger boys are provided to do this for him. The use of messenger and tool boys is in almost all shops an economical move, since their time in the aggregate represents less money than that of the mechanics who shut down their machines when they go to the tool crib or the stock room. Another method of solving the oil problem is to have a supply tank and measuring pump mounted on a truck, and wheeled through the departments by an "oil peddler," who can see that the producer's wants are supplied.

**247. Economies in the use of cutting oils.** The substitution of cutting compound for cutting oils is a matter of considerable saving. Some managers are, however, averse to using cutting compounds on expensive and complicated machines, on account of a possible tendency to gum and to demulsify into oily substance and plain water, with consequent rust of equipment. This is a debated question, and without going into the merits of it, it is sufficient to state that where oil is used for cutting purposes it is economy to regain as much of this as possible from the chips and product pieces. Draining the product in sieves or riddles over oil tanks is one method of doing this, but not as efficient a one as separating by centrifugal action. Machines are on the market for this purpose. Their first cost is not great, nor is much power required to operate them, a few hours a day being sufficient as a rule to take care of chips and product from ten to twelve screw machines. Practically all of the oil is regained through this process. It will hardly pay to extend this refinement to regaining cutting compound, however, on account of its low cost.

**248. Regaining oil from waste and wiping rags.** Considerable oil may be regained from these materials by use of steam cookers and settling apparatus. Aside from the oil regained, the material is rendered fit for further use which in itself is quite an economy.

**249. Use of central oil storage stations.** Large plants effect economies in storage and delivery of oil through the use of central oil storage stations from which oil is piped to various parts of the plant, being delivered under pressure by means of pumps. The delivery of oil which is supplied in this manner may be regulated by means of self-measuring pumps which are provided with locking devices of which those in authority have the keys.

The storage of oil in tanks instead of in the original barrels is a source of economy, since all oil barrels leak more or less. Some plants avoid this loss while still retaining the oil in the original barrel by means of concrete barrel space excavations arranged with drains to return whatever oil leaks out.

**250. Methods of handling waste and wiping rags.** (Refer to paragraph 446.)

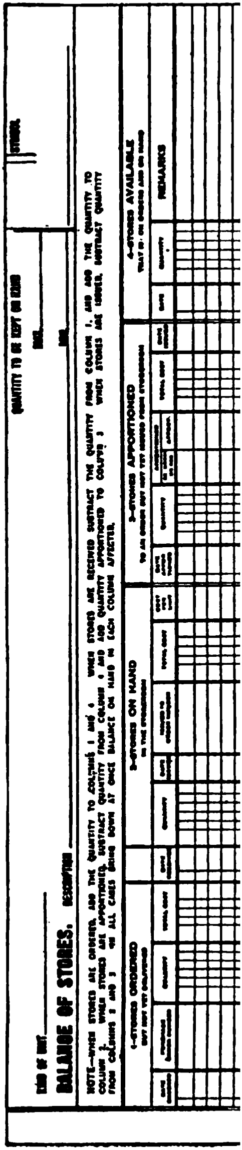
**251. Methods of handling foreign material kept in stock for ...nent with manufactured goods.** Often material is purchased

and held in the stock room for shipment with customers' orders. A convenient method of handling such material when its size will permit, is to place it in bins which are given the order numbers of the shipment on which the material is to go. Where the size of material will not permit of this, a tag should be attached to it containing the order number and other particulars sufficient to fully identify it.

**252. Precautions in connection with issue of valves and pipe fittings.** This class of material forms a popular division of stores, a great deal of which is liable to find its way out of the shop unless extreme precautions are taken to prevent this. The fact that the stockkeeper is in charge of this material should not be accepted as the only check. A good way is to require, with the issue of all material of this kind, a description of where it is to be used, either referring to the order number, if a productive order, or the shop location if used on shop repairs or extensions. This will enable the checking up of such items whenever thought necessary.

**253. Sub-stores.** For convenience in making deliveries of material, store rooms may be located in various departments, somewhat on the principle of the supplementary tool cribs mentioned in (162). Supplies of nuts, bolts, washers, and other material largely used by the assembling departments are kept in such cribs in the assembling department. In the machine department we find oils, waste, and other supplies frequently used and generally kept in the department tool crib.

The necessity for a subdivision of stores in a plant is determined



by the amount of time taken by employees in walking back and forth from the store department and may be eliminated altogether by use of special messengers for this purpose. When this is done the expense of maintaining messenger service will probably be less in a moderate sized plant than that of keeping up a number of sub-store departments and employing storekeepers for this purpose. This argument does not hold good, however, when the functions of the tool crib and stores are combined in one department.

**254. Perpetual stores inventory.** One complete form of stores inventory is illustrated in Fig. 131. This is used at the Watertown Arsenal to keep track of the purchased materials. It will be noticed that stores are apportioned on this record form for the purpose of determining what quantity of each item is available over and above orders. Purchases of new material are made more frequently by reference to this figure than to the actual amount of material on hand. Sometimes the perpetual stores inventory does not apportion or take account of material on orders, in which case its form and the method of maintaining it are the same as for the perpetual stock inventory described in (177–178) and illustrated in Fig. 128. The simple form of stores inventory necessitates physical inventory at the start to determine what is on hand, and is maintained thereafter by a report of receipts and stores disbursements, which correct the balance on hand. When stores are apportioned, two more reports are required for the maintenance of the inventory cards, namely, a record of orders received, and a record of shipments.

## PHYSICAL INVENTORY

**255. Physical inventory methods.** When a complete physical inventory is to be taken, if the results are to be of any value, it must be done with the plant shut down for a sufficient period for the amounts to be properly obtained and recorded. The steps in taking a physical inventory may be divided into three: (*a*) preparation, (*b*) actual count, (*c*) extension and computation.

**256. Preparations for a physical inventory** should be thoroughly made to minimize the time required and number of mistakes. In this connection, preliminary organization is necessary, in which every one understands just what he has to do in connection with the inventory. Sheets are provided for recording the data, which are usually subdivided between material and labor, and further between goods in process, rough and finished; also sometimes between commodities, such as purchased materials and manufactured parts, and even between the materials such as cast iron, steel castings, bronze, brass and the like.

**257. If the inventory is to be taken by weight,** a sufficient number of scales must be provided so that there will be no delay in the matter of weighing. Where individual costs are accurate, weights are not needed, the count being sufficient and the weights and values being taken from the individual cost sheets.

Additional preparation for the inventory may be made on material that does not move rapidly, by preliminary counts on material arranged in piles, each pile provided with a tag which is

corrected for additions or withdrawals in similar manner to the bin tag described in (241).

**258. Where a perpetual inventory system is used,** physical inventory may be distributed throughout the year, as described in (242), and taken without shutting down the plant.

**259. The actual work** of taking the inventory depends upon whether it is taken by weight or by count. If the former, the gang may well be divided into callers-off, weighers and checkers, the latter usually being clerks who can record the results in legible writing.

Where the inventory is taken by count, the weighers, of course, are not necessary, nor need a large number of scales be provided.

**260. The computing of an inventory** is made simple by means of systematic handling. An organization for this purpose is quite necessary, usually consisting of every one in the office who is available for this purpose. These are distributed into several groups, the first putting the price opposite each item, the second group making the extension into total cost, the third group checking the extension, the fourth group making the addition on each sheet, and a fifth group, if necessary, classifying sheets and adding sheet totals. A convenient method of handling the material between groups is by means of wire baskets, in which the sheets completed by one group are placed, to be drawn by the next. The fullness of any basket indicates the necessity of enforcing or withdrawing men from a given group, and is a great convenience to the one who is in charge of the inventory. Where work is handled in this manner, an inventory of a large plant employing several thousand men has been completed in 24 hours after the last report was turned in by the shop.

**261. Where accurate individual costs are not obtainable,** it is sometimes possible to classify the products into groups, and apply to these groups unit-weight prices. The rough material price is easily arrived at from the foundry cost, that of finished material is estimated by taking account for a period of time of the pay-roll in certain departments, and the total weight of material passing through, which gives a fairly close figure. Work in process is assumed to be halfway between the rough and finished, which is probably correct on the average.

## INSPECTION

**262. The nature of inspection.** Inspection may be broadly defined as the determination of values. As commonly used, the word is applied to the determination of quality values only, but it may be still further extended to the determination of time or cost values in which case it becomes known as time study, or again, to the determination of quantity values which merge into stockkeeping systems and methods.

Inspection may have for its purpose the grading of the commodity examined into different classes, or its definite acceptance or rejection.

As described in this section, inspection will be regarded in its common meaning, as applied to quality.

**263. Classification of defects.** Inspection exists because of the existence of defects and if it were not for this we would have no necessity for it. Defects may be divided into three classes:

Defects due to design.
Defects due to material.
Defects due to workmanship.

**264. Organization of inspection department.** While the work of inspection is not always carried on by a distinct department organized for that purpose, this is the logical and best proceeding where the shop is large enough to afford it. It is necessary in arranging the organization that the inspector shall be free from interference or coercion from any member of the department to which he is assigned. For this reason the inspection department is usually responsible directly to the works management, which is as much interested in maintaining quality, as quantity, although this cannot always be said of the heads of individual departments. Occa-

**INSPECTION REPORT**

Date 6/12/14 Number 1841 By Jones

SIZE ______ **VERTICAL BOILER**

| | | | |
|---|---|---|---|
| Test to 200 lb. hydrostatic pressure | | | O.K. |
| Safety Valve adjusted to 125 lb? | | | O.K. |
| Rivet Heads? | | | O.K. |
| Plates Edges? | | | Rough |
| Stay Bolts? | | | O.K. |
| Are following fittings in place? | | | |
| Pressure Gage | X | Water Column | X |
| Blowoff Valve | X | Injector | X |

REMARKS-
Plate edges rough on vertical lap joint

FIG. 132.—Instruction card and inspection report.

sionally an inspection department is found which is under the direct control of the engineering department. This is usually on that class of work which may be called engineering construction as distinguished from straight manufacturing.

**265. Instruction cards for inspectors.** The same advantages that are found in the use of instruction cards for shop operations, apply to the inspection operations. This is especially true in the case of complete machine assembly, where there are a number of points to be checked up. This may also be compared to the checking list used in the drafting department. A representative instruction card is shown in Fig. 132.

In the case of piece or operation inspection, instructions to inspector are sometimes contained on the drawings, as for example

when maximum and minimum size limits are given or the degree of finish is represented by a symbol (see 74). Inspection cards are also used for parts and contain information as to these points when they are not covered by the drawings. In a great many plants, neither limits nor degree of finish are specified, these being left to the judgment of the inspector. When he is a graduate of the department concerned and familiar with the requirements of accuracy this works fairly well, but allows opportunity for considerable leeway in the matter of opinion as to what is passable. The principle of standardization demands specific information for inspection, both for the benefit of those who make the inspections and the men whose work is concerned.

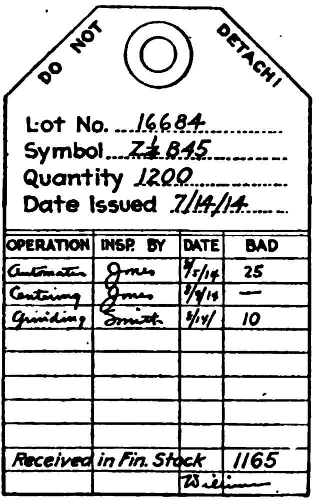



FIG. 133.—Travelling inspection tag.

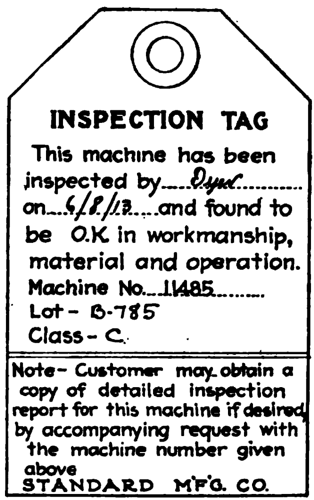



FIG. 134.—Finished machine inspection tag.

**266. Inspection tags.** Inspection tags are used for two purposes. First, to follow the work through the shop and indicate the inspections which it has passed, and second, to be shipped with the complete machine to the purchaser as an indication that it has received final inspection. Both types of tag are shown in Figs. 133 and 134. The shop tag may be applied to an individual piece, in the case of large work, or it may accompany a tray or tote box full of small parts through the successive operations.

**267. Personnel of inspecting force and general duties.** Where several inspectors are employed, a chief inspector is usually in charge of them. His duties are to supervise the work of the inspectors, and to settle any disputes or questions which may arise over their decisions. The chief inspector usually has the final and supreme

decision on all matters covered by inspection. It is also part of his duty so to arrange his subordinates as to keep them busy and to properly care for the total work of the plant.

**268. Physical arrangement of inspection.** The ideal system is to have a *separate inspection room* for each department, into which all work is brought after finishing, and from which it is taken to the stores department, to be reissued for a subsequent operation if necessary, or for assembling into machine units or a complete machine. An arrangement of this kind gives a positive check and avoids the opportunity for working the same piece in twice, which has been known to happen.

Where the work consists of large and bulky pieces this is not a feasible scheme as it involves too much transportation. In this case it is necessary to leave the work in the department. Duplication and errors are avoided by the use of steel inspection stamps, usually more or less complicated in design to prevent imitation. This stamp is applied to the part inspected after it is passed.

**269. Specifications as an aid to inspecting purchased material.** Definite specifications help the inspector to determine if purchased material is to be passed or rejected. These specifications if properly made out require considerable time and thought applied to each commodity. Materials which are repeatedly purchased and used for plant consumption are conveniently covered by specification. Among them may be mentioned, belting, oils, waste, paints, lumber, roofing, and the like. Among product parts and materials; metals, in ingot or cast form, structural shapes, bars, and so on are usually included.

An example of a purchase specification used by the Westinghouse Electric & Manufacturing Co., is given below. It is taken from an article published in the American Machinist, vol. 34, p. 976, by C. B. Auel. It is not only a good example of a complete purchase specification, but is of value in indicating the requirements of first-class belting.

## Leather Belting Specification

*General.* This specification is intended to cover miscellaneous sizes of leather belting for general use.

*Material.* Belting must be of the best quality of oak-tanned leather, free from all ingredients in any way injurious to the life or wearing qualities of a belt, or that simply add to its weight.

*Location of cuts.* Belting must be cut longitudinally; no piece of hide must exceed 54 inches long; widths less than 7 inches to be cut within 15 inches of the center of the hide; widths 7 inches and over to be cut from the center; neither shoulder, belly, side, nor flank stock, nor any padding or shimming will be permitted; it must be of uniform thickness and width, and be perfectly straight from end to end.

Under a strong magnifying glass the way in which the leather has been cut, whether longitudinally or crosswise, may generally be determined by the follicles or hair cells, and if their direction is other than longitudinal, this may be considered cause for the rejection of the length of belting under inspection.

*Laps.* Laps must not be less than 4, nor more than 8 inches excepting that [illegible] belting 8 inches and over wide, the lap may be 1 inch longer than the [illegible] of the belting; no lap should be within 4 inches of the end of a strip. [illegible] be thoroughly cemented and when pulled apart, the exposed [illegible] not show any resinous, vitreous, oily or watery condition; [illegible] be permitted.

*Weight.* Belting not waterproofed must come within the following range of weights, which must be guaranteed to be not more than 10 per cent. in excess of the actual weight of the leather.

**Single Belting**

| Width in inches | Minimum weight, ounces per square foot |
| --- | --- |
| 1 to 2 | 13 |
| 2¼ to 4 | 14 |
| 4½ to 5½ | 15 |
| 6 and over | 16 |

**Double Belting**

| Width in inches | Minimum weight, ounces per square foot |
| --- | --- |
| 1 to 2 | 24 |
| 2¼ to 4 | 26 |
| 4½ and over | 28 |

*Physical properties.* Belting must have an ultimate tensile strength, both in the leather and in the splice, of not less than 3600 pounds per square inch and must not show an elongation in 2 inches to exceed 13½ per cent., when measured under load of 2250 pounds per square inch for 1 hour.

Belting must not crack open on the grain side when doubled strongly by hand with the grain side on the outside, nor must it show piping or raising on the grain side when similarly treated with the grain side on the inside.

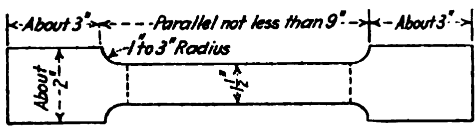



FIG. 135.—Leather belt test piece.

Test pieces having the following dimensions for tensile strength and elongation will be cut from belting with a die. (See Fig. 135.)

When belting is required for any special purpose, the manufacturer will be notified as to the nature of the work, the maximum horse power, speed, and the like.

*Making.* Belting must contain the manufacturer's name, trade mark or the equivalent, on every 10 ft.

*Rejection.* The Westinghouse Electric and Manufacturing Co., reserves the right to reject any portion or all of the material which does not conform to the above specifications in every particular and to return the rejected material to the manufacturer or seller for full credit at price charged f.o.b. point of delivery specified by the purchaser. If the material is to be replaced, a new order will be entered at prices, terms and conditions acceptable to the purchaser.

**270. Various inspection methods applied to various manufactures.** The nature of the inspection will vary according to that of the product. For example, in the steel ball manufacturing trade the product has necessitated the development of special measuring machines and devices in addition to special inspection methods, in which the actual work of inspection is largely accomplished by girls. Machine tools require inspection for accuracy of alignment of work holding and tool holding parts in addition to the inspection of the various parts for individual accuracy and finish. Engines and motors require additional entirely different, tests with a view to determining their efficiency. In outlining an inspection system, one of the first things is to determine what inspections are necessary, before deciding how they shall be made.

**271. Material inspection.** The inspection of material in the state received is known as material inspection, although it really consists in detecting defective labor in most cases, since raw materials used in machine-shop practice are few. Among them may perhaps be included pig iron, other metal ingots, sand and clay. Raw materials are best inspected by chemical analysis when their quality can be established thereby. Iron and steel shapes are often subjected to physcial tests for strength, as in fact all metals used in construction. Lubricating oils are tested for body, viscosity and coefficient of friction. Chemical and physical tests do not necessitate a complete laboratory for this purpose, although many large plants maintain them. The small plant may obtain the services of public laboratories for this purpose at a nominal charge. Oftentimes inferior products are delivered to the small plant on the assumption that these tests will not be made, so it is a good plan to have them made occasionally as a matter of policy. Where pig iron is bought to analysis it is quite important to check this up, especially when bad castings are experienced. An ounce or two of chips drilled from a number of pigs selected at random from the pile will be sufficient for analyzing purposes. If the analysis of the pig is checked against a similar analysis made by obtaining chips from the castings themselves, considerable light may often be thrown on the cause of the trouble.

**272. Inspecting material at the source.** Material is often inspected at the source, either by means of inspectors who are sent from the purchasing plant, or through the service of consulting engineers who provide men for this purpose. This plan is adopted particularly where the amount of material involved runs into large sums, or the freight would be a considerable item, as for instance in the case of a special rolled metal section to meet certain specifications for strength. In this case the manufacturer is quite likely to insist on inspection of the material as it is being made so that there will be no doubt of its acceptance afterward. When material is inspected at the source, it is unnecessary to say that each piece or part should be stamped or marked in such way as to be easily identified as inspected, and to prevent the shipment of uninspected material. The only inspection when received need be for the presence or absence of this mark.

**273. Inspecting material when received.** This is an important part of the duties of an inspection department, since it is customary not to allow for labor spent on defective material discovered after it is worked upon. The method of organizing the routine to cover this was described under purchasing, in (178–186). *The proper time for this inspection* is immediately after the goods are received and before they are delivered to stores. Unfortunately in some cases it is impossible to detect defects until cuts have removed the surface of the material, as in the case of interior flaws in steel forgings and bars, internal blowholes in cast iron, steel and malleable castings and the like.

**274. Design inspection.** The inspection for design was covered under drafting room management, in (88). Errors which are not detected are constantly slipping through, resulting in loss due to

defective design. The only thing to do in this case is to see that they are promptly corrected, and to charge them up to the defective design account.

**275. Records of defects.** Records of defects according to the three principal classes into which they fall, design, material, and

| DEFECT REPORT | | | | | |
|---|---|---|---|---|---|
| DEPARTMENT Drill | DATE 6/4/13 | PIECE B6 | QUANTITY 1 | REPORT BY Jones | |
| DEFECT Internal Blow Hole | | | | CHARGE TO OPERATOR No | |
| | | | | PREVIOUS OPERATIONS DONE Bore Mill Drill | |
| WEIGHT 10# | MAT'L. VALVE .25 | SCRAP VALVE .08 | MAT'L. LOSS .17 | LABOR LOSS .25 | |
| Total Cost of Defect, including Overhead | | | | $0.83 | |
| PATTERN | LATHE DEPT. | DRILL DEPT. | DESIGN | | |
| FOUNDRY X | PLANER DEPT. | ASSEMBLY DEPT. | MATERIAL X | | |
| | | | WORKMANSHIP | | |

FIG. 136.—Defect report.

workmanship, should be kept, either by weekly or monthly periods. Further classification into departments is desirable. The Westinghouse Electric & Manufacturing Co. tabulate these graphically as shown in Figs. 137 and 137*a*.

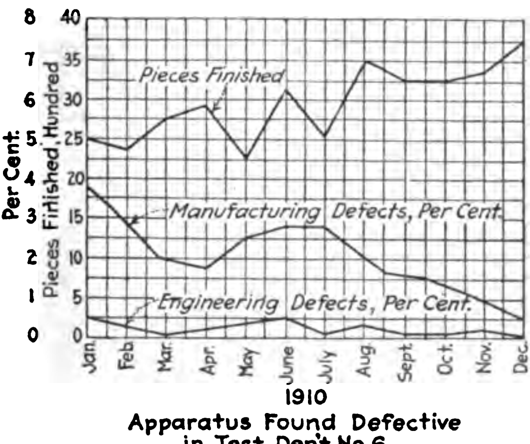



FIG. 137.—Graphical defective report.

*To obtain proper information* regarding defectives, defective slips are used in some plants to record them as discovered and assist in the tabulation of the periodical report. One of these is shown

in Fig. 136. These slips may also serve to indicate whether or not the defect is chargeable against the operator, in the case of piecework or other special compensation systems in which corrections of pay are made on this basis.

**276. Various persons employed to inspect for workmanship.** While as a general rule, inspectors are employed for this purpose there are exceptions. In some cases the foreman of the department acts as the inspector in addition to his other numerous duties. In such cases the inspection cannot of necessity be thorough. Practically the only form possible is selective inspection,

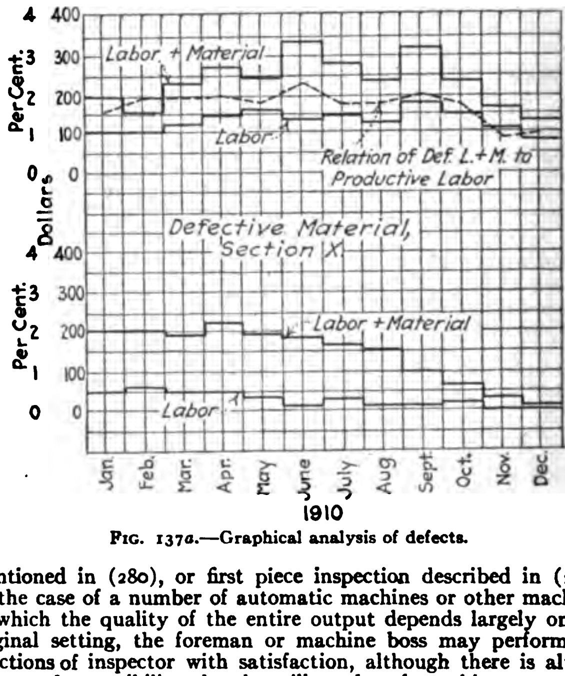



FIG. 137a.—Graphical analysis of defects.

mentioned in (280), or first piece inspection described in (279). In the case of a number of automatic machines or other machines in which the quality of the entire output depends largely on the original setting, the foreman or machine boss may perform the functions of inspector with satisfaction, although there is always present the possibility that he will tend to favor his own output record.

Sometimes the workman himself acts as inspector. In one plant where there were few changes in the personnel of the working force this scheme was adopted with success on the screw machines. This was made feasible owing to the fact that similar work or repeat orders always went to the same individual so that responsibility for poor workmanship could be traced back to him, no matter where or when discovered.

Another scheme in which the workman acts as inspector, is where

he performs work on a part that has been previously worked upon by someone else, and is held accountable for all labor which he puts on a defective or spoiled piece. It is therefore up to him to be on the lookout for such pieces and to report them to keep his count clear.

**277. Operation inspection** is the inspection of each operation as distinguished from the inspection of the completed piece. It is necessary when the labor involved on previous operations would amount to a great deal if the defect were not discovered until the piece was finished. This form is commonly used on large work, in which case it applies to each piece put through. On small work, where operation inspection is employed, it is in connection with first piece (see 279) or selective (see 280) inspection, since it would be too costly to examine every operation on each piece in quantity production.

**278. Piece inspection.** Where the operations are but few, and their cost is little, it is sufficient to make an inspection of the completed piece, all operations being considered at that time. This may be done selectively, or on each piece put through depending on the class of work involved. Part inspection saves transportation when a closed system of stockkeeping is employed, since the piece may remain in the department until completed.

**279. First piece inspection.** Sometimes only the first piece is inspected. This is in cases where the machine employed depends for the accuracy of the product on the original setting up, and where several thousand pieces may be produced after this without the necessity of further inspection. Particularly in the case of automatic screw machines working on soft bar stock at moderate speeds and feeds. Sometimes the first piece inspection is combined with successive inspections at more or less regular periods, as every hour, or every half day. Press work may be included under this heading.

**280. Selective inspection.** This is based on the law of averages or probabilities. For example, if ten pieces selected at random from a lot of 100 were inspected and found to be satisfactory, the probabilities would be strongly in favor of the remaining ones being so also. In case some of the ten were found defective it would be advisable to examine further into the lot, possibly inspecting each piece. Selective inspection is practically the only possible way to examine the thousands of parts which come from automatic machines, stamping presses and the like, where individual inspection would add enormously to the cost. It is figured that the few pieces which should slip through under this system will be discovered and discarded before they are combined into the finished machine, providing there is a serious defect present.

**281. Inspection of unit assemblies.** Aside from the methods of piece inspection described above, the method of inspecting unit assemblies may be used. This is especially valuable in the automobile industry, where it would be a much more expensive matter to test for all defects in all units only in the completed car. So thorough is the unit assembly inspection in the Ford plant, that no test of the finished car is thought necessary.

**282. Operative inspection.** This is usually the final test of the complete machine. It varies as to the purpose of the machine, and is more specialized for this reason than any other inspection. In the case of an engine it would consist of taking indicator cards, applying a load, testing for overload endurance, testing the bearings for heat, the governor for regulation, and so on. Instruction cards are absolutely necessary for such a test, but are usually in the form of reports to be filled in by the tester and recorded under the machine number. Where unit assembly tests can be made it reduces the work of the final test, although not so always, as in the case of a steam engine or a machine tool where much depends upon the accuracy of the final assembly.

**283. Inspection of the complete machine by designing department.** In the case of engineering constructions and particularly where machinery is built to the customers' drawings and specifications, it is sometimes the rule to have a representative of the drafting department make a final check of the completed machine against the drawings, so that there will be no chance for a "come back." This is in addition to the operative test, which may or may not have been made under the supervision of this department.

**284. Shipping inspection.** Especially on material which is fragile, or which is boxed for export or liable to rough handling in transit, an inspection of the material after crating or boxing is desirable. It is not necessary on all material shipped, in some plants but few items a week would require it, but judging from the number of complaints received from this source a small investment along these lines would be profitable. Such procedure should investigate not only the actual crating and the completeness of the shipment, but the lettering and marking of the consignment.

**285. Other various inspections.** In addition to the foregoing which have been solely connected with product, there is plant inspection and equipment inspection. These may be further divided as follows.

*Plant Inspection.*
- As to maintenance of buildings.
- As to maintenance of grounds and arrangement of materials.

*Equipment Inspection.*
- As to maintenance of machine tools and productive machinery.
- As to condition of small tools, jigs, fixtures.
- As to the transmission equipment, belts, pulleys.
- As to transportation facilities.
- As to safety devices, fire protection.
- As to sanitary conveniences.

Most of these topics have been treated in separate headings under equipment. Inspection of these details is as vital to the successful management of a plant as the careful inspection of the product for quality; especially of the last two which have to do with the safety of the employees as well as insuring an uninterrupted course of manufacture.

The general principle involved in all of the above cases is to ... assign responsibility for each item; arrange for regular ... and insure formal reports of such inspection. The

state, and fire insurance and accident insurance companies conduct such inspections, but this should not be construed as sufficient.

## ROUTING

**286. Routing.** Routing may be defined as the selection of paths over which the product parts travel during their transformation from rough to finished pieces. It is *standardization of sequences*. Its object is to determine the lines of least cost for each particular part, and then insure that these lines are followed.

*Routing is distinct from dispatching, but must precede it,* inasmuch as we must have definitely planned routes before we can assign time schedules for arriving and departing at the various stations. It is not always followed by the use of a dispatching system however, for many plants whose output is too complicated to consider controlling or dispatching the elements according to definite time schedules, can profit by routing.

**287.** *One of the advantages of routing* is the saving effected in mental energy of those in charge. In the shop where routing is not done, the foreman must arrive at a decision regarding each piece machined under his jurisdiction, with regard to:

What operations are to be performed?
In what order or sequence?

For each operation:
What machine is best fitted for it?
Which operator can do it to best advantage?

These decisions all require concentration of mind, take time and mental effort both of which must be conserved as the average foreman has plenty of demands upon them without spending them unnecessarily. Again, best results are not obtained in the quick thinking necessary on such matters where instant decision must be made, and the efficiency of the department suffers in consequence of improperly assigned work. Routing simply does the thinking and makes the decisions once and records them so that they are on hand whenever the part comes through again.

Shop activities, with the millions of parts traversing an endless variety of paths, are infinitely more complicated than all of the railroad train operations that occur daily in our country. The analogy to the train is a close one however, the part starting from a certain point, stopping at others and finally reaching the terminal. A train run from San Francisco to New York without a pre-determined route, the tracks and station stops being selected according to the judgment of each relieving conductor, might reach its destination eventually, but it would be an example of inefficient and dangerous operation, and it could not possibly get to the destination on time. The same degree of inefficiency exists in the plant where the various department heads exercise the decisions regarding the sequence and nature of operations on the parts machined in their departments.

**288. Planning the routes.** Probably the most logical place to plan the routes is in the drafting room. (See 92.) Here a control of design is possible to suit manufacturing conditions. The prac-

tical experience which is to be found in the shop and which is sometimes deficient in the drafting room, may be combined by the use of committee work on new design, as indicated in (35).

Wherever the planning of routes is done the principles to be considered are the same. The order in which they are to be taken up is as follows.

**289.** (*a*) **What operations are necessary?** This is not a difficult problem, but it gives rise to opportunities for changes in design on new parts that would not be thought of except in connection with this subject. The degree of accuracy with which each operation must be performed is to be considered at this point, as having large bearing on the subsequent planning.

**290.** (*b*) **The proper sequence of operations.** This subject is to be considered from several viewpoints. In quantity manufacture, the jig design for various operations will depend largely upon the state of completion of the part subsequent to the operation considered. Those which require the most careful location need the advantage of already finished surfaces to locate from. Flat surfaces are always desirable in placing work upon machine tables, since it avoids wedging and shimming up, thus saving considerable unnecessary time. Enclosing jigs, which are necessarily heavier than the part contained often raise the total weight limit to a point which makes handling an inconvenience. Where location is from a finished bore or hole, the enclosing jig may often be replaced by a template or attached jig weighing but a fraction as much.

**291. Another point to consider** is the general line of travel through the shop, especially in routing large work. In this case, the machine location to a large extent determines the routing, for if the planers are nearest the foundry door it would be advisable and save transportation if this work is done first. Sometimes routing instead of being secondary to machine location, becomes the underlying element in location of machines and even in the construction of the plant. (See 144.)

**292.** (*c*) **The machine or machines best adapted to perform each operation.** Those who do the routing must have complete information at hand regarding the capacities of all machines in the plant. This is best handled in the form of data sheets, shown in Fig. 11. In addition to this there must be available a knowledge of the peculiar characteristics of the various machines outside of their actual capacities which makes one machine superior for certain work when compared with another almost identical in type. Often the capability of the operator comes into the question of routing, especially on difficult work which requires great accuracy, or on work which must be kept down to the limit in cost on account of selling price. As an example of the latter, the low rates of apprentices may often be made available to rescue some low-priced job from absolute loss of profit.

Routing is of sufficient importance to apply it to all of the information available from other sources such as time-study, records [illegible]ts, and the like. It should also consider inspection layout as [illegible] of routing, designation of what inspections are necessary [illegible]orporated upon the route cards.

**293. Selective machine routing.** When standard parts are routed, it is often desirable to denote a variety of routes which are permissible, to provide flexibility of control.

This is especially so when it is not considered wise to plan all actions from a central office, but to allow the foremen of departments considerable leeway in arranging their work to avoid congestion. In a case of this kind, there are certain machines which might be used for a given operation, and certain ones which would not be under any circumstances. If preferences in the matter of machines be indicated by the arrangement of their numbers on the route card, and the numbers of all which could possibly be used for a given operation be included, this selective routing relieves the foreman of considerable thought without detracting in the least from his personal control of the department. Examples of selective machine routing are shown in Fig. 140.

**294. Degrees of routing.**

(*a*) DEPARTMENT ROUTING. (Fig 138.)

Route Card

Part—Main Bracket for Working Head.
Pattern No. Z-245. Drawing 6-236.

1. Foundry.
2. Cleaning shed.
3. Planing department.
4. Turret lathe department.
5. Lathe department.
6. Drilling machine department.
7. Assembling department.

(*b*) OPERATION ROUTING. (Fig. 139.)

Route Card

Part—Main Bracket for Working Head.
Pattern No. Z-245 Drawing 6-236.

1. Mold.
2. Clean.
3. Sand blast.
4. Plane side and bottom.
5. Bore main hole.
6. Bore side hole.
7. Turn tit. Inspect.
8. Drill for head piece.
9. Drill for side lever pin.
10. Drill oil hole.
11. Assemble. Inspect.

(*c*) STANDARD PART SELECTIVE MACHINE ROUTING, USING SYMBOLS. (Fig. 140.)

Route Card

Part Z-245.

| Operation | Department | Machine | |
|---|---|---|---|
| 1–P. 1 and 2 | M.2 | 670 or 674 | |
| 2–B.3. | M.6 | 42 | |
| 3–B.4 | M.6 | 120 or 125 | |
| 4–T.5. | M.3 | 14–15 or 16. | Inspect. |
| 5–D.6. | M.9 | 141 or 148 | |
| 6–D.7. | M.9 | 141 or 148 | |
| 7–D.8. | M.9 | 160–161–164 or 167 | |
| 8–A. | M.4 | (Gang 3). | Inspect. |

**295. Degrees of routing.** The degrees of routing may vary from a simple designation of the departments which are to receive and work on the part, stated in consecutive order, to a schedule which involves each operation and designates the particular machine to

do it. Examples of various degrees of routing are shown in Figs. 138, 139 and 140. That shown in 138 is an elementary form designating departments only, but is of great value if used for nothing

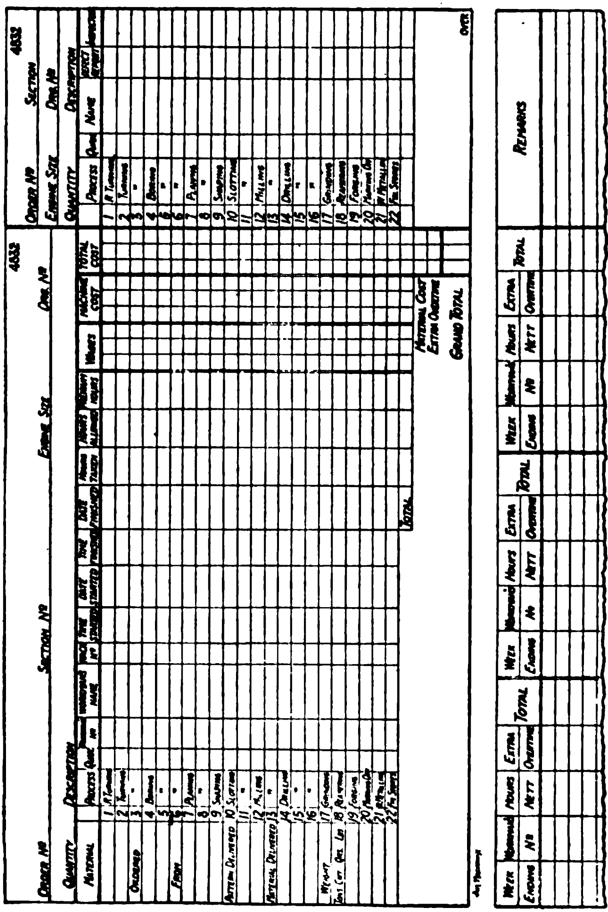



FIG. 141.—Combined tracing and routing sheet.

else than as a guide to the proper issue of orders. This is especially true where new production clerks are employed who have no knowledge of the practice of the shop.

**296. Forms for recording routes.** These are almost infinite in variety and number according to the degree of routing entailed and

the complexity of the processes. In many cases the route-forms are combined with other functions, such as tracing sheets. This is especially true where special orders are routed and their duplication is not frequent. On standard repeated parts it is more economical to have permanent independent route cards for each part which are filed in a card index under the symbol or drawing number of the part and which are referred to as required. An example of a sheet which combines the tracing and routing functions is shown in Fig. 141.

**297. Routing as a basis for plant arrangement and machine location.** In "one-product" shops, the route traveled by the part should determine the arrangement of the machines, the transportation facilities and even the form and design of the plant buildings, to secure a minimum cost of production. When the work becomes more complex it is difficult to find one definite arrangement which will be equally suitable to all parts going through. However, there is always one plan that will be the best on the average. The determination of this is helped largely through a study of the route cards in connection with the weights and quantities of parts handled, by means of which the amount of transportation for various arrangements can be mapped and judgment of the best arrangement made easy. (See Fig. 46.)

**298. Using the route cards in laying out transportation facilities.** An efficient transportation system must accommodate itself to the paths of the product. Routing forms a basis for judging the nature of the transportation facilities required, their location and extent. The route cards, and the "transportation factor" obtained by multiplying the product of the weights, quantities and length of paths, give definite help in laying out transportation schemes.

**299. Connecting the routes with shop activities.** A simple determination of the best routes and sequences is of no value unless it be applied and followed. How this is done depends on the structure of the shop-order system, with which routing is intimately connected. Where a central planning department is installed, all orders originate from this department, therefore the routes are designated upon the orders at this point, or origin of the order, by the order clerk. The manner of doing this will depend on whether operation orders or complete process orders are used. In the first case the individual operation order tickets will be made out specifying the machine or selective machines to do the work. In the latter case, a route ticket or job card will probably accompany the work from one machine to another, portions of it being detached and sent in when the operations are finished, as a means of locating the progress of the order. In other cases the transportation of the material is also handled from the production office, "move tickets," or move orders being issued, directing from where and to where certain work is to be transported, Fig. 163.

**300. Where work is routed from the drafting room,** the results are recorded in the shop office on cards, the procedure after this being the same as above described for standard parts. Special orders and new designs which are not standard sometimes have the route sheet attached to the list of parts, or incorporated to form a part of

it. (See Fig. 141.) This gives an illustration of a form in which three functions are combined, namely, the bill of material, route sheet and tracing sheet.

**301. Where the control is to be vested with the department foreman,** he is provided with selective route cards for filing in a convenient index in his department. Either he, or his clerk refers to these cards in connection with the work orders received, and notes upon them the machine and man number to do the work. Special orders under this plan would be routed only as to operations required, the selection of the machines being left to the foreman.

**302. Relation of routing to time and cost keeping.** The value of definite routing is indirectly but effectively reflected in more accurate costs. This is because the various steps in the process concerned are definitely standardized, so that there is no chance for a misunderstanding as to what is included in a given time report. The degree of refinement of time-keeping must therefore depend on the degree of routing employed, for when separate time is kept on individual operations it is quite necessary that these operations and their sequence be listed.

**303. Relation of routing to stores.** While routing is not immediately connected with the ordering of stores or maintaining the balance of stores, the route sheet especially when combined with a tracing sheet is often used as a source of information for the issue of stores orders for the purchased parts that go with the material under construction. Where the bill of material route sheet is used, the items of stores are included under each production item and tickets calling for their delivery may be made out as soon as the order is received. These tickets are then placed in "work ahead" racks where they remain until called for by the assembling foreman or other individual having need of them. This scheme relieves the foreman of clerical work, and in addition provides a means of checking the various items of stores to anticipate future required deliveries. Where the transportation system is employed, the move men receiving their orders directly from the production office, these stores orders are filled and delivered by the move men at the time that the castings are taken to the assembling bench or floor.

**304. Routing in the small shop.** It is unfortunate that some of the features which have existed under good common-sense management for years should be attributed strictly to new management systems which have simply given them a name. For instance, every capable foreman has conducted a routing system of one kind or another, either in his head or on paper, or both. One of the most useful applications to the small shop consists of the note book kept by the foreman, in which new work is recorded as to how it was performed, by whom, the tools used and the results. Nowadays we would call this routing, time study, tool-standardization, and so on. It really comprises most of the valuable points of all of these things and is a mighty useful thing to turn to when the same piece occurs again. In the small shop, the limited number of machines makes it desirable to combine this record of the sequence of operations with sketches of the tool set-up and possibly time

records of the results, since the foreman who compiles this information is likely to have rate-setting as one of his accomplishments in case piece or premium or like methods are installed. In case a book of this kind is to be kept, and it is highly desirable and profitable for the small shop foreman or superintendent to do so, let it be of pocket size with detachable or loose leaf pages, since as this matter grows it will have to be arranged differently from time to time. One page of such a book is illustrated in Fig. 142. It is not necessary to have printed forms for this purpose, plain blank paper will answer the purpose, for it should be remembered that forms are only conveniences and have nothing to do with the value of what is written in the spaces provided. And it is better to have a common note book with thumb prints on its pages testifying to its use, than fireproof steel filing cabinets full of beautifully engraved forms that are filled and filed mechanically but seldom used.

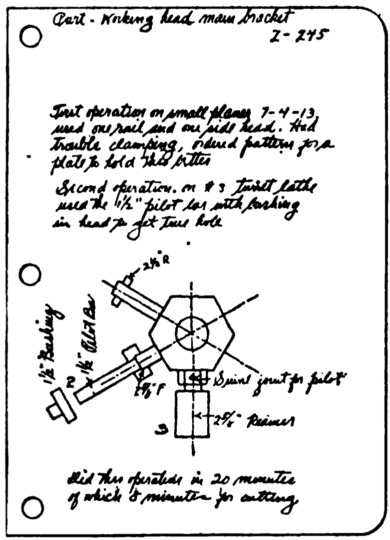



FIG. 142.—The small-shop foreman's note book.

## DISPATCHING

**305. Dispatching.** Dispatching in the factory is similar in purpose to train dispatching, namely, to start a piece at a given time and to be able to know when it is going to arrive. It is unlike it in this way, that whereas on a railroad line the dispatcher has to do with not more than a dozen trains a day at the most, the factory dispatcher has to do with hundreds of pieces, and they travel more different roads than all the railroad systems in the country. From this, it may be seen that it is a difficult proposition, and one that has been worked out to a detailed success in but few shops. And those plants have been what may be called "one-product" shops, although some of them make several sizes and modifications of the same product.

**306. Dispatching is possibly the last refinement** in specialized manufacturing, for routing, time study and standardization must necessarily precede it. For to dispatch we must know the route, and to set the proper time for the article to be finished we must know how long each operation is going to take. We must also know the exact condition of each department with respect to pres-

ent orders, or how far up to capacity it is, so that we can plan when the piece in question may be put through it without interfering with something else.

**307. A dispatching system comprises the following elements:** (*a*) *An index of route cards* showing the standard routing for each piece.

(*b*) *Individual order blanks* which are filled out for each "station" on the route showing the arriving and departing time of the work.

(*c*) *A capacity record* for each department or "station" which shows how much work is already in that department and permits dates to be assigned for the various operations.

(*d*) *A follow up*, or tracing system by which the operations are kept from falling behind. This may be compared to the station blackboard which shows how far each train is behind schedule or whether it is on time.

Route cards used in dispatching are the same in principle as those described under "Routing" (287-299).

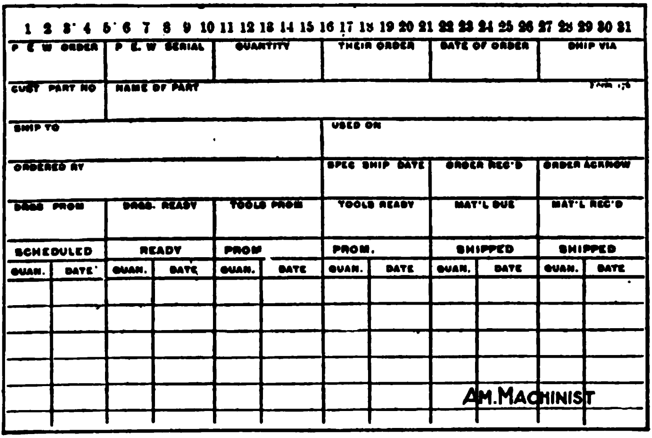
The individual order blanks may be of any particular form. Work ahead orders are sometimes held in the central production office, and sometimes kept in the department which is to do the work. This depends upon whether the policy is to load all machines from the central production office, or to load departments only, and load the machine through the directions of someone in the department. Returns in any event must be made on all orders to the central production office so that the follow-up records may show that the article has passed a given point.

**308.** (*e*) **Follow-up systems** are of many kinds, some operating with cards and some using a ledger or book scheme. The principle of all of them is the same, namely, to record the date of passing station points, and to show up all orders which are delayed so that they may be put on a "black" list and given special attention. At the Cleveland Twist Drill Co.'s plant, the follow-up cards are held in open racks by individual clips, so that the right-hand edge of each one is visible. On this edge are printed the various dates in the month, and indicators are slipped over the card showing the date that it is due at the station. When that day arrives, the follow-up clerk in making his inspection of the cards will note the ones that are due and pull them out for investigation. Of course these cards are transferred from rack to rack as the piece in question proceeds, and the indicator is changed to show when due at the next station.

It may be imagined that the large variety shop and the jobbing shop would have their hands full in attempting to operate a full dispatching system. Various modifications of this, however, in the form of "Steering Systems" and "Tracing Sheets" are in use for such plants and for others who do not wish to go into such refinements but still feel the need of some systematic way of following work through the shop.

**309. The successful use of a production control** scheme of any ıd is closely connected with the method of issuing shop orders, g slips, and so on. As before mentioned, complete control

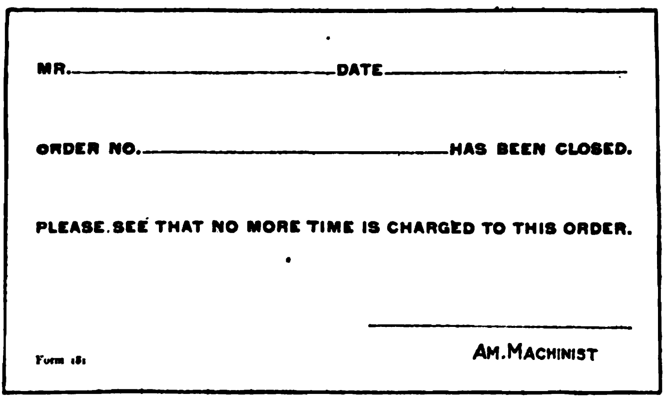
of production is a possibility only when the time required for each operation is definitely known. Bearing this fact in mind when considering the advisability of installing such methods of control will often save money and wasted effort.


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

| P. E. W. ORDER | | P. E. W. SERIAL | | QUANTITY | | THEIR ORDER | | DATE OF ORDER | | SHIP VIA | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CUST. PART NO. | | NAME OF PART | | | | | | | | | |
| SHIP TO | | | | | | USED ON | | | | | |
| ORDERED BY | | | | | | SPEC. SHIP DATE | | ORDER REC'D | | ORDER ACKNOW. | |
| DRGS. PROM. | | DRGS. READY | | TOOLS PROM. | | TOOLS READY | | MAT'L DUE | | MAT'L REC'D | |
| SCHEDULED | | READY | | PROM. | | PROM. | | SHIPPED | | SHIPPED | |
| QUAN. | DATE | QUAN. | DATE | QUAN. | DATE | QUAN. | DATE | QUAN. | DATE | QUAN. | DATE |

AM. MACHINIST

Fig. 143.—Master card.


MR.__________DATE__________

ORDER NO.__________HAS BEEN CLOSED.

PLEASE SEE THAT NO MORE TIME IS CHARGED TO THIS ORDER.

Form 181

AM. MACHINIST

Fig. 144.—Information slip.

**310.** A frequent method of scheduling is by means of work tickets for jobs ahead placed in racks arranged to represent the various machines or assembling gangs. A system of this kind was described by Henry W. Johnson, in the American Machinist, vol. 40, p. 225, being that used by the Providence Engineering Works

to keep track and control the efforts of 400 men working on lots varying from 1000 complete auto trucks to a single gear for a local garage.

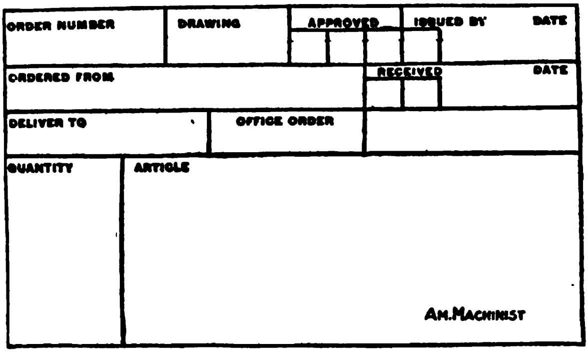



FIG. 145.—Stock and stores order.

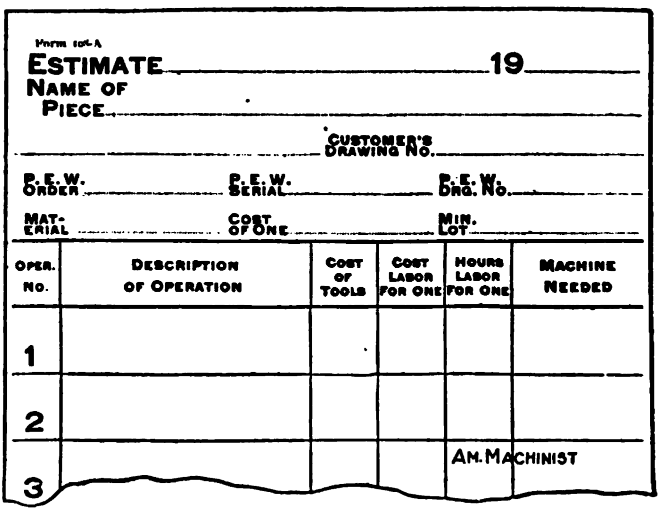



FIG. 146.—Tool equipment estimate.

A card, which is termed the "master card" is filed in the superintendent's office, and is used to keep track of the work in general, metal clips being slipped over the dates on the top of the d indicating when the order requires attention. Notes are made

on the backs of these cards relative to correspondence with customer, data, and the like.

From these notes information is given the various departments on forms such as indicated in Fig. 144.

Production lists are compiled by the engineering department. From this list material is ordered, both purchased and such as is

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

| TOOL NO. | TOOL DRAW. NO. | SERIAL NO. | SERIAL DRAW. NO. |
|---|---|---|---|
| ORDER NO | OPERATION NO. | | DATE |
| NAME OF TOOL | | | |

| DATES | DRAWINGS | PATTERNS | MATERIAL | COMPLETE |
|---|---|---|---|---|
| WANTED | | | | |
| SPECIFIED | | | | |
| FINISHED | | | | |
| EST. COST | ACTUAL COST | Form 212 REMARKS | | |

AM.MACHINIST

FIG. 147.—Tool record.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

| TOOL NO. | TOOL DRAWING NO. | SERIAL NO. | SERIAL DRAW. NO. |
|---|---|---|---|
| ORDER NO. | OPERATION NO. | DRAWINGS WANTED | DRAWINGS FINISHED |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

IF NOT NOTIFIED TO THE CONTRARY WITHIN 24 HOURS IT WILL BE ASSUMED THAT DATE ABOVE SPECIFIED CAN BE MET.

AM.MACHINIST Form 211

FIG. 148.—Tool requisition.

manufactured. Receiving slips are sent to the scheduling department as soon as outside material is received, so that the records may be checked. This material remains under the control of the stock-keeper until requisitioned by the scheduling department on forms shown in Fig. 145.

14

A scheduling system, particularly when it must handle new work, must be connected definitely with a systematic method of providing tools to do this work, which must also be completed on schedule so as not to delay production. In the plant described, it is the duty of the engineering department to make drawings of the tools necessary immediately after completing the shop drawings. This is done in connection with committee consultations between the head of the tool department, the chief tool designer and the foremen of departments concerned. Operation lists, on a form indicated in Fig. 146 prove of value in this connection.

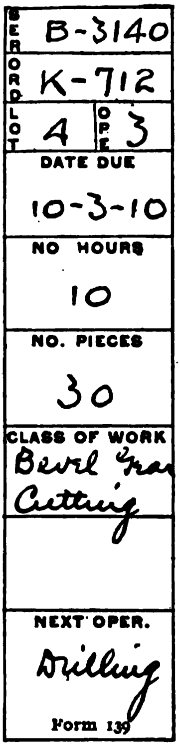



FIG. 149.—Control tickets.

Tool requisitions such as shown in Figs. 147 and 148 follow this, calling for the delivery of the tools at a certain date and providing space for the inspector's signature, which indicates that they are O.K. for the job.

The actual control of production is through individual work tickets shown in Fig. 149, which are made out for each lot and operation. These are filed in slits on a scheduling board, the slits being 1/32 inch wide and 1 inch long, ninety-six slits to a column and twenty-four columns to a board. Each board represents 3 months in time, the line of slits running cross-ways representing the days of the month, and the vertical columns representing machine tools, each board representing 3 months' work of twenty-four machine tools. Sometimes tools of a similar character are grouped together, the work being assigned to the group instead of to individual tools. Various signal flags, shown in Fig. 150, represent various factors or conditions in connection with the job ticket, and are placed ahead of the job ticket in the slit. Thus a red number indicates the day that the job has been received at the machine and is ready to be worked upon, and a black one indicates that work has commenced.

The work of placing these signals is done by a scheduling clerk who receives his information through slips sent in from the shop, some of which are shown in Figs. 151, 152 and 153.

Through these methods, the actual state of the work in all details is apparent upon the scheduling boards. The foremen of the various departments are encouraged to consult these boards frequently. In addition to this, control is exercised through sending inquiries to the various foremen in the cases of parts falling behind schedule, calling for explanation. Fig. 154 represents one of these.

Traveling slips, called travelers, Fig. 155 which correspond to job tickets, are sent through the shop in connection with the pieces

to be machined. When a lot is split for any reason, the color of the traveler is changed, becoming blue, whereas the original one was buff. Red travelers are used to indicate rush work. The cost of scheduling work in the shop described was $90 per week, being done by one chief clerk and six assistants, a great deal of the work being accomplished by inexperienced men or boys.

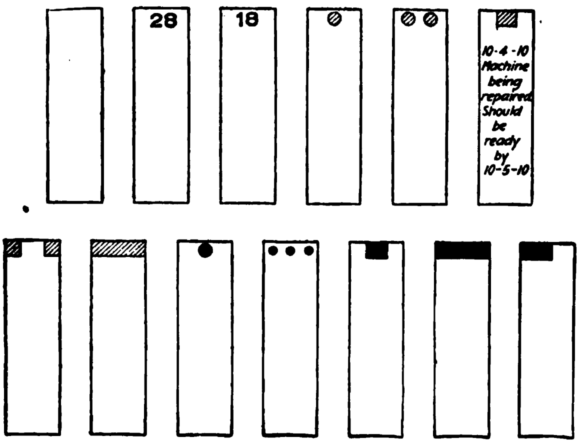
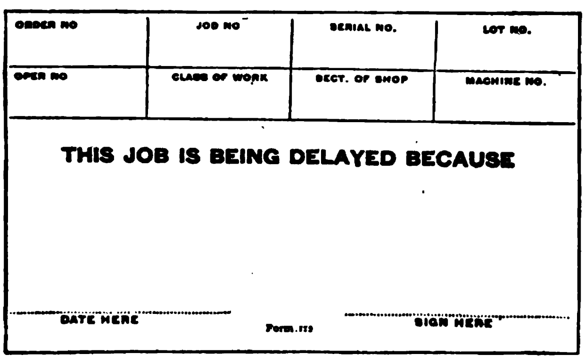



FIG. 150.—Signal.



| ORDER NO | JOB NO | SERIAL NO. | LOT NO. |
|---|---|---|---|
| OPER NO | CLASS OF WORK | SECT. OF SHOP | MACHINE NO. |

THIS JOB IS BEING DELAYED BECAUSE

DATE HERE Form 173 SIGN HERE

FIG. 151.—Delay slip.

The above description will serve to impress the point that a scheduling system must not only be based on accurate time study, but must have the other shop system elements arranged in conformity to it, so that the whole may work to one end.

| ORDER NO | JOB NO | SERIAL NO | LOT NO. |
|---|---|---|---|
| OPER NO | CLASS OF WORK | SECT OF SHOP | MACHINE NO. |

THIS JOB WAS
FINISHED

.................................A. M. P. M. ........................................191........

Form 140 ........................................ SIGN HERE

FIG. 152.—Finish slip.

| ORDER NO. | JOB NO. | SERIAL NO. | LOT NO. |
|---|---|---|---|
| OPER NO. | CLASS OF WORK | SECT OF SHOP | MACHINE NO. |

THIS JOB WAS
STARTED

.................................A. M. P. M. ........................................191........

Form 110 ........................................ SIGN HERE

FIG. 153.—Starting slip.

| Order No. | Job No. | Serial No. | Lot No. |
|---|---|---|---|
| Oper. No. | Class of Work | Sect. of Shop | Machine No. |

Mr...........................

We think that the above job due to have been started on............................has been ready to work on for..................days. If there was any reason why this work could not be started, other than work ahead, a Delayed slip should have been sent in. Please give this work your attention, advise on back of this slip what is delaying you and when you expect to start, and return this slip to the

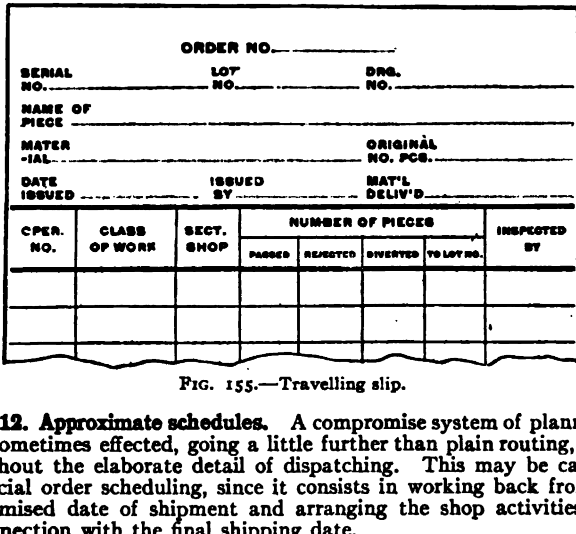
SCHEDULING DEPT.

Form 160—[illegible]

FIG. 154.—Notification that parts are ready for processing.

## SCHEDULING

**311. In operating a scheduling system,** care must be taken to see that the system runs the shop, and not the shop the system. In many plants, expensive records are the result of such work, records, since they come after the fact and not before it as they should. In installing a system of this kind, it is hardly necessary to say that after it has been carefully studied out and planned to meet every possible contingency or thought-of objection, it should be installed part at a time, commencing with the group of machines which appears to be the easiest to handle, and extending it only after this group is under thorough control. If it is put in as a whole, confusion is sure to result and the result will likely be so discouraging as to call for abandonment of efforts along those lines.


ORDER NO. ____________

SERIAL NO. ________ LOT NO. ________ DRG. NO. ________

NAME OF PIECE ____________

MATERIAL ________ ORIGINAL NO. PCS. ________

DATE ISSUED ________ ISSUED BY ________ MAT'L DELIV'D ________

| OPER. NO. | CLASS OF WORK | SECT. SHOP | NUMBER OF PIECES | | | | INSPECTED BY |
|---|---|---|---|---|---|---|---|
| | | | PASSED | REJECTED | DIVERTED | TO LOT NO. | |
| | | | | | | | |
| | | | | | | | |

FIG. 155.—Travelling slip.

**312. Approximate schedules.** A compromise system of planning is sometimes effected, going a little further than plain routing, but without the elaborate detail of dispatching. This may be called special order scheduling, since it consists in working back from a promised date of shipment and arranging the shop activities in connection with the final shipping date.

A system of this kind is helpful in keeping promises of shipment inasmuch as it is a step in advance of hit or miss methods; but must be used with judgment as otherwise it will work injustice to orders which have not been definitely promised for shipment but which are side-tracked on account of the scheduled orders. To avoid this, the promises made on shipments should be rather made as a result of the preliminary scheduling, and based upon what is found to be possible.

**313. Mechanical helps in controlling production.** Various mechanical schemes are used for control, tracing, and so on, and are based upon the theory that graphical or mechanical elements are more easily grasped and their real meaning made more apparent

FIG. 156.—H. H. Franklin Co.'s control board.

than a simple collection of numerical figures. In other words, figures are monotonous and have little individuality to the average clerk, who will handle them as provided by routine but will not grasp the actual meaning which is essential for successful results. A production board also has the advantage of being accessible or visible to a large number of people who are interested in production, therefore matters needing attention are more likely to get it.

**314.** The H. H. Franklin Co., of Syracuse, manufacturers of the Franklin car, have a most complete production board upon which all events are planned, timed and traced. Horizontal distances are considered as units of time. Thus, each working day is

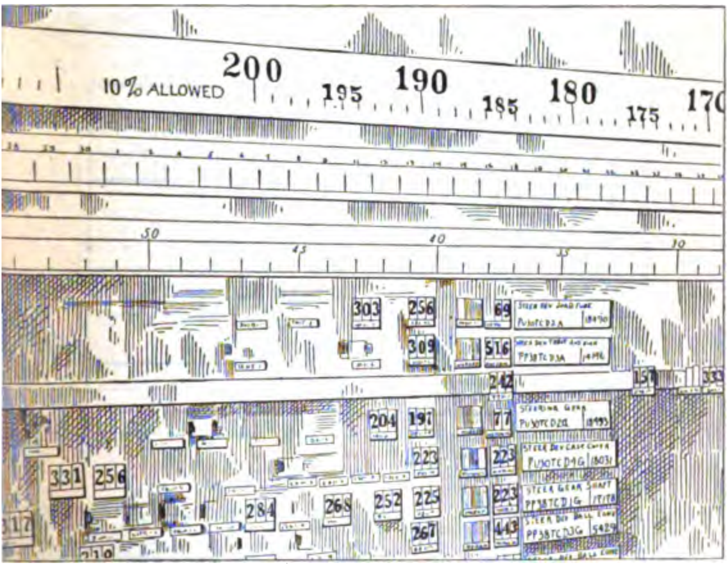



FIG. 157.—Detail of the stations.

represented by a half inch of space. Every operation or event in connection with building a car is shown upon this board. The length of time required for such operations has been previously accurately determined by time study; without this information a system of this kind could not be operated. The manufacturing schedule which is determined by the management to meet the demands of the coming season, is used first to lay out the required quantities and final assembling dates, which from the information already at hand and laid out upon the board, determine the timing for each previous event in the entire process. This is then translated upon the control board into a planned performance

schedule, so that the position in working days ahead of the finishing date is shown for each event. As the work proceeds, the attainment results are noted upon the board in connection with the planned dates, only those which are behind schedule being subject for attention. This board is arranged with mechanical conveniences and is thus described by Geo. D. Babcock, production manager of the Franklin Co.

It became evident from an early study of this plan that charts or drawings would not be sufficiently flexible to carry it out with economy and comfort, and a mechanical device was designed and constructed in our works which seems to have fulfilled this requirement perfectly. It is rather elaborate in its form. Fig. 156 will give a general idea of construction and layout. This illustrates the master control board. The detail of the stations is shown in Fig. 157. The white block sets of each station which includes the number and base marker are ½ inch square and stand 2 inches out from the board.

NAME Spiral Gear Bkt Bush DIVISION HEADSTOCK PIECE No. 4550
DWG. No. 12740 MATERIAL C.9 STYLE No.
No. PER MACHINE 2

| JOBS | 147 | 168 | 205 | |
|---|---|---|---|---|
| ORDERED FROM | B.9.F | B.9.F | B.9.F | |
| ORDER No. | 23219 | 246 | 2101 | |
| No. ORDERED | 100 | 103 | 103 | |
| DATE ORDERED | 1/26 | 4/25-10 | 1/12 | |
| DATE DUE | | | 2/15 | |
| DATE and No. RECEIVED | 2/14 101 | 4/6 72 | [illegible] | |

REMARKS 48 on hand after 168

FIG. 158.—Bullard master card.

The face of the board is made of ⅛ × ⅛-inch metal strips. The cages of vanadium steel can be clipped on to the strips at any point. The face of the strips can be slid horizontally and allowed to rest, thus changing the position of any particular part but maintaining the time setting of each event of the part. The board can be opened at any place and one or more new parts inserted.

The complete record of our work is taken from these boards by photographs. The time saved by this and the fact that we pay no attention to items that are up to schedule has more than offset the cost of preparation of the equipment and is now a continuous asset.

The fact that all our data are displayed publicly to our supervising force, and also that all individuals throughout the works receive their instructions from this source maintains a high degree of accuracy, much higher than we were ever able to obtain when using paper records.

From the standard board as shown and through the mechanism of the board, the schedule section write and date manufacturing orders, job cards, stores issues, move tickets, and tags. Any set rate of acceleration or uniform effort can be changed by the production manager inside of a few hours and the whole scheme of date of production be changed within 20 days to exactly agree with the new plan, and this without confusion. If we wait 20 days after any such change the orders in the works will have expired and the new orders with new dates will follow into process.

**315. Dispatching at the Bullard plant.** A chart system of dispatching and planning is used by the Bullard Machine Tool Co. of Bridgeport, Conn. (American Machinist, vol. 34, p. 1066.)

The permanent written and plotted records used solely for this work of routing and controlling consist of two files of cards and two sets of charts. One card file is for the master cards, the other for the operation cards. One series of charts gives the departmental capacity and progress of jobs for each shop department; the other series gives the progress of each job, both completed and uncompleted, from the time of installing the system.

Other shop records are used as a source of information, but all of these were in use in their present form prior to the adopting of the methods being described.

As a temporary record a letter is sent to each department foreman every Monday morning scheduling the work to be done in his department during that week.

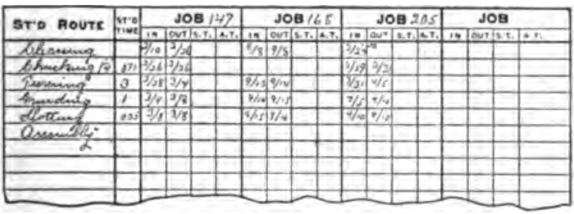



FIG. 159.—Tracing sheet.

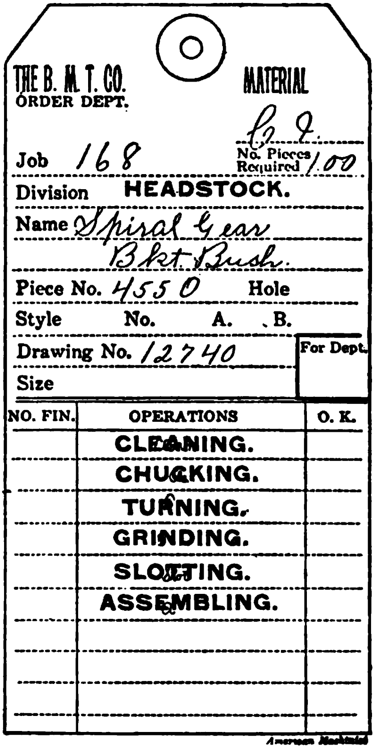
For the ensuing week please arrange to spend time as follows:

| Jobs | Hours |
|---|---|
| 1 | 200 |
| 2 | 50 |
| 3 | 200 |
| 4 | 200 |
| 5 | Finish. |
| 6 | Finish. |
| 7 | Finish. |

The master card serves for four successive lots of machines. In Figs. 158 and 159 three lot numbers are shown, 147, 168 and 205, with the fourth column blank for the next order. The data in these columns concern raw material. The first four items are filled in by the order clerk when he placed the outside order. The line, "date due," is filled in, depending upon the need of the shop, and the information upon which it is based comes from the department charts.

Coincident with the filling in of the first four items on the master card by the order clerk, he writes a corresponding work tag (see Fig. 160). If the rough stock corresponding with this tag is in the storeroom, the tag is immediately passed to the clerk who cares for the master- and operation-card files. In case the rough stock is not on hand the tag is filed by the order clerk until it is received.

A specimen operation card is shown by Fig. 161. There is one



THE B. M. T. CO. ORDER DEPT. MATERIAL

C. I.

Job 168 No. Pieces Required 100

Division HEADSTOCK.

Name Spiral Gear Bkt Bush.

Piece No. 4550 Hole

Style No. A. B.

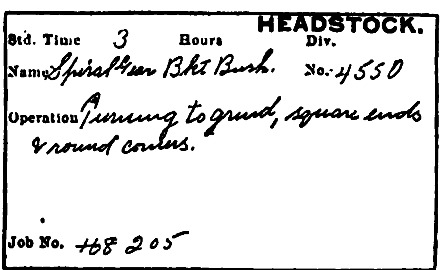
Drawing No. 12740 For Dept.

Size

| NO. FIN. | OPERATIONS | O. K. |
|---|---|---|
| | CLEANING. | |
| | CHUCKING. | |
| | TURNING. | |
| | GRINDING. | |
| | SLOTTING. | |
| | ASSEMBLING. | |
| | | |
| | | |
| | | |
| | | |

American Machinist

FIG. 160.—Travelling tag.



Std. Time 3 Hours HEADSTOCK. Div.

Name Spiral Gear Bkt Bush. No. 4550

Operation Turning to grind, square ends & round corners.

Job No. 168 205

American Machinist

FIG. 161.—Operation order.

such card for each operation on every piece manufactured. These cards are used over and over again as successive lots are made by merely changing lot numbers.

*The control is by means of charts*, one of which is shown in Fig. 162. The heavy black lines on this chart represent the standard hours which it is planned that the jobs will take. The dotted lines are filled in from week to week and indicate the actual number of hours

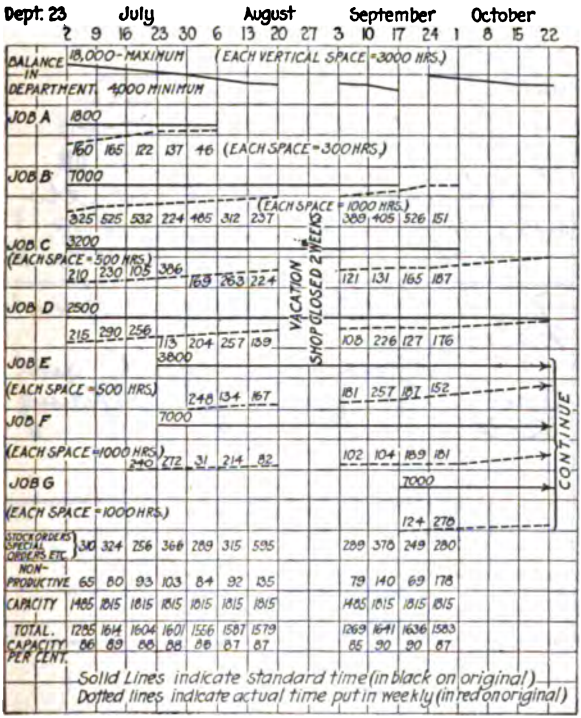



FIG. 162.—Bullard control chart.

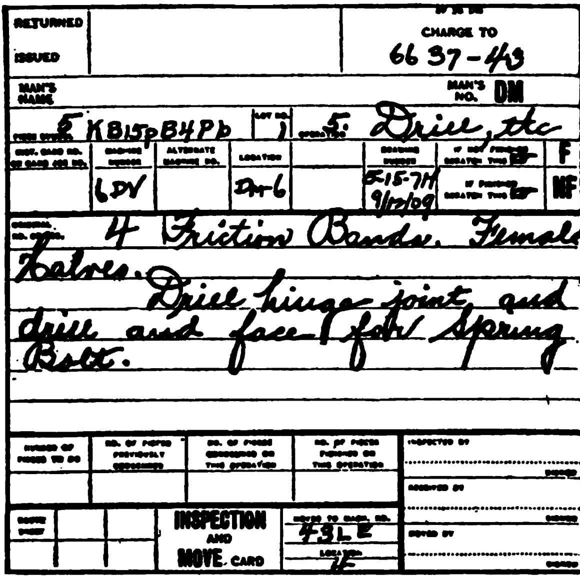
that have been applied to each job. Thus it may be seen from the nearness of approach of the two lines how near the job is to completion. A system of this kind is only possible where standard time has been determined with a great degree of accuracy.

An additional chart on the same plan as the one shown is also used, to distinguish between department and machine capacities.

## STEERING AND TRACING

**316. "Steering" and "tracing systems."** Steering sheets are provided with spaces whereby dates are entered when the various

pieces pass given machines on their way to completion. Often this form and the bill of material may be one and the same, originating in the drafting department. (See Fig. 15.) Columns are provided for the principal machines. It is not usually necessary to check up each operation, as even when there is no definite routing followed, certain classes of machine work are done first and certain ones last. Drilling, for example, is usually a final operation, and when a piece is marked past the planers, boring machines and at the drilling machines, its state of completion is pretty well defined to any one in the business.



RETURNED
ISSUED
CHARGE TO
66 37-43
MAN'S NAME
MAN'S NO. DM
5 KB15pB4Pb 1 5 Drill, etc.
F
6DV Dr-6 5-15-7H 9/12/09
NF
4 Friction Bands. Female Halves. Drill hinge joint, and drill and face for Spring Bolt.
INSPECTED BY
RECEIVED BY
INSPECTION AND MOVE CARD
43LE
MOVED BY

FIG. 163.—Inspection and move ticket.

*The steering sheets* are kept up, or entries made through the agency or either the returned machine orders or the daily time cards, on which there is a space for "operation completed." When the steering-sheet clerk sees this on a time card, he makes the entry in the proper column of the order and under the name of the part concerned. Thus the department head can at any time judge of the status of an order by looking at the page in question. This method is particularly well adapted to keeping track of special orders, such as occur in a jobbing shop.

**317. Relations between dispatching and transportation.** If dispatching is to be effective, it must insure that the "next job" is at hand at the machine before the scheduled time arrived for the given operation upon it. To this end, a transportation system

must be installed, and its efforts controlled through the dispatcher's office. Cards known as "*move tickets*" are commonly used to convey orders to the "move men." These are of various forms to suit conditions, sometimes being made out for individual orders and filed with the work tickets, and sometimes issued in complete sets to cover the entire movements of a given lot. A combination move and inspection ticket which is used by the U. S. Government at the Watertown Arsenal is shown, Fig. 163.

As a rule, all orders and work tickets sent out from the dispatcher's office are returned when the work called for is completed, the return being a notification of completion. The return of move tickets shows that the work is at a given machine, and removes any excuse for broken dates on account of lack of material.

**318. Steering sheets** should be of such size as to be readily transported about the shop, so that the clerk who has charge of them can carry them about "on the job" to verify certain items, or even to do some checking in advance on certain jobs. The successful use of a steering sheet depends much on the capability of the man in charge of the entries. If it is done in a purely mechanical way it is not worth the expense of keeping it up, but if this clerk uses his book as a means of calling delays and making suggestions to the department heads, it will be a paying investment. The amount of work required to keep up a book of this kind is not as much as might be imagined. Certain parts will not have to be traced at all if they are in stock finished as is usually the case. In some plants it is always the details that hold back orders, in others it is the large work, depending on the relative machining capacity for the two kinds of work. Where this is the case, steering or tracing the parts which are usually the last to come through will help production greatly. The use of common sense in this connection is the principal element of success.

**319. Relation between dispatching and tool supply.** It is as necessary to have the proper tools on the job as to have the materials. One of the aims of dispatching being to keep the producers busy at their machines, the question of tool supply naturally becomes a part of it. Tool tickets are made out for each part and operation, and are filed in the control board along with the work and move tickets, until the work becomes due. At this time the tool tickets are sent to the tool room. They not only specify what tools are required, but act as move orders to the tool department, who are required to deliver them to the given destination, collecting the proper number of tool checks from the man at the time of delivery.

**320. Relation between dispatching and inspection.** On standard work, the inspectors have a definite idea of their duties and their routine does not need to be covered by individual inspection orders. On special work, however, these are necessary, and are issued by the dispatcher the same as work and move tickets. They tell the inspector what to inspect and where to find it. The return of the inspection ticket to the dispatcher denotes whether the part is acceptable or not, and controls the further steps to be taken. Returned inspection tickets are usually kept and filed as a matter of record, whereas returned work and move tickets are destroyed.

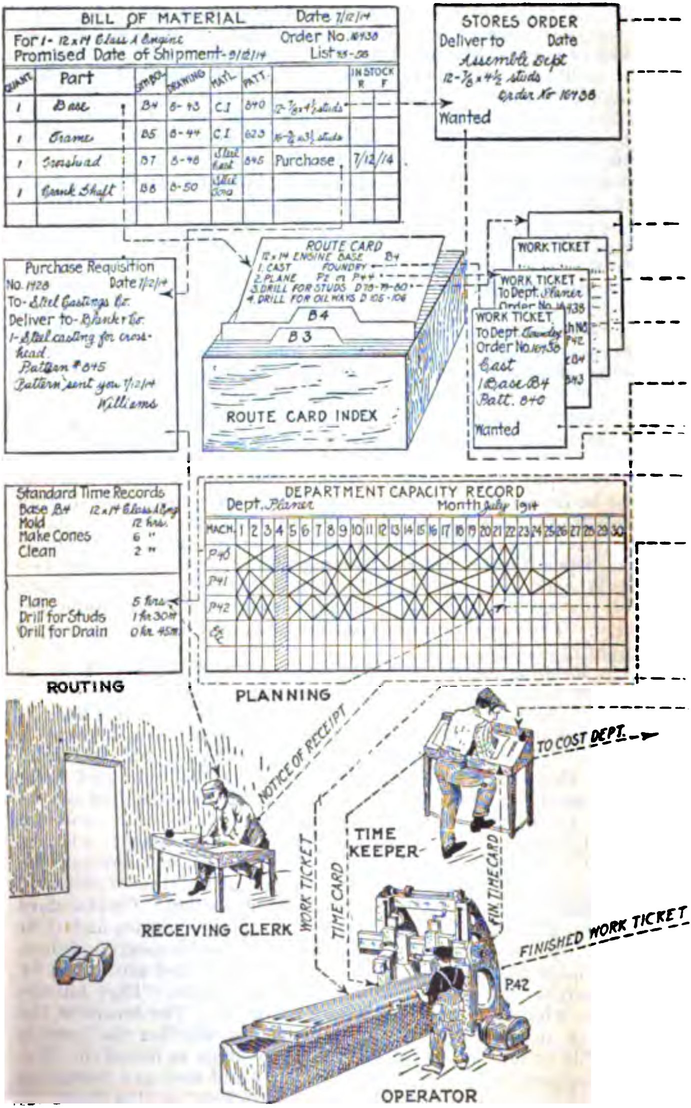
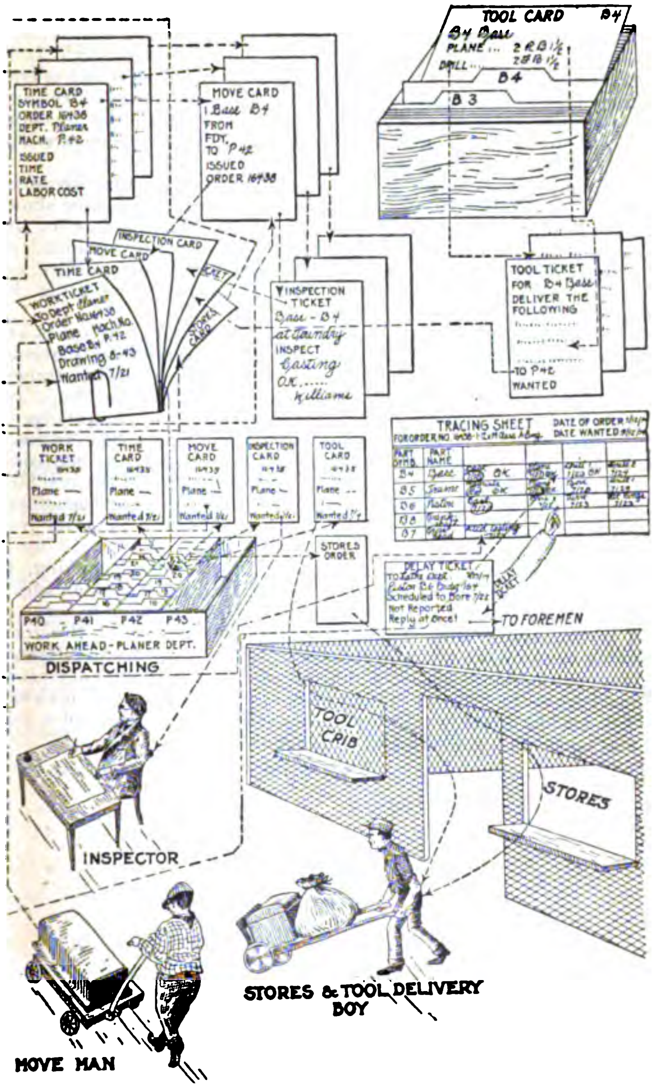



**Fig. 164.—Relations between routing, plan-**




ning, dispatching, tracing and shop activities.

**321.** *Routing takes care of laying down the tracks.* Also of providing the forms which will be used in planning and dispatching. The example given in Fig. 164 is of operation routing. It is intended in connection with this to keep time on individual operations, take care of transportation from the production office, and in this connection also supply the required tools to the machine at the proper time. Required stores are also to be delivered to the workman requiring them.

Planning necessitates a close knowledge of the time required for the job at hand, also a capacity record for each machine showing how much work ahead it has in hours, so that the date for the operation in question may be placed. After this is determined, the various order tickets connected with each operation are filed together under the date selected, and in a division representing the machine that is to do the work.

When the date arrives for the work in question, the cards are pulled out, separated and sent to their respective destinations. Telephone and messenger service is used to expedite things. It must be understood that the planned dates in many shops are quite approximately placed, owing to lack of definite knowledge of the time required, or of unforeseen conditions which arise. In cases of this kind, the various cards are shifted as often as necessary in the work ahead trays, according to the capacity of the machine in question, the main requirement being to keep all the machines loaded the greatest possible percentage of time, and wherever possible, to have from 3 days' to 2 weeks' work ahead.

*Tracing is used as a check* on the results of dispatching, to see that the work comes out as planned, and to ask the reason why if it does not. Sometimes the dispatching board is made to serve as a tracing board also. Usually separate forms are used, the items being connected under the order number for convenient reference since it would be a matter of difficulty to locate the parts of a given machine in the work ahead files without cross-reference of this kind. The tracing sheet is a record of the state of completion of a job, and serves as a guide in issuing assembling orders.

# SECTION V

# TIME AND COST CONTROL

## TIMEKEEPING

**322. Timekeeping methods.** Timekeeping is made to serve several purposes. Originally, it was to see that the employee put in the number of hours of work that he was paid for. The next step was to classify this time or divide it up according to the work done during the day, giving the labor costs on the work done. This has been extended and elaborated in general, until we have the present methods of timekeeping and time recording, inseparably bound up with costs and forming the basis for them. In fact, timekeeping and the influence of the proper use of time records on productive capacity, have made this of secondary importance only to the actual work itself.

Aside from the mechanical methods of timekeeping, there are several ways that it may be done "by hand." A common scheme is to provide the employee with a pad of time cards and allow

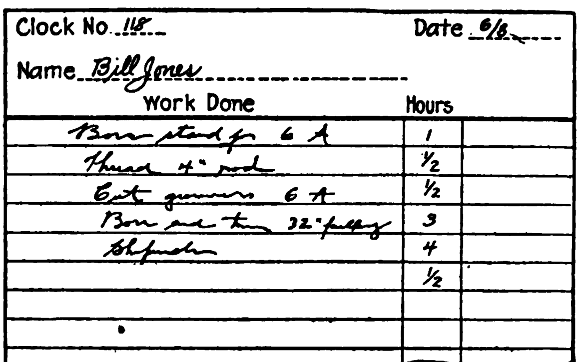



FIG. 165.—A crude and illegible time card.

him to fill them in at the end of the day. Fig. 165 illustrates a time card of this type. This is as poor a method as could well be devised if any use is intended to be made of the records after they are turned in. For if the man happens to remember all of the jobs worked upon during the day, he will have a more difficult task in assigning such time to each as will balance out his full day, which is the point about which he is most particular, and not to get accuracy on the individual items. In addition to this, there will be a number of entries on one time card and it will consequently be impossible to sort them according to any subject except man's

number, which is of use only in computing the pay-roll. Another objection is in the various styles of handwriting which are to be found in the shop and which as a rule do not follow any known rules or system and are consequently hard to decipher. Still another disadvantage is that operations will be lumped at one time and separated at another, and the time clerk who looks over the cards will be at a loss to tell whether a time record is high or low.

A step in advance of this is to have the *workman fill cards for each operation*, providing the department with a clock or clocks which are visible from all parts so that the time will be somewhat near correct. These cards are filled out at the termination of the operation and not at the end of the day. A form sometimes used is shown at Fig. 166. This has the advantage over the first method in more accurate results, and less time spent by the workman, but it

| | | | | | |
|---|---|---|---|---|---|
| Clock No. 118.. | | | | Date 6/10... | |
| Name Bill Jones | | | | | |
| Part 32" Pulley | | | | | |
| Quantity | | | Operation Finished | | |
| Bore | Face | Turn | Thread | Counterbore | |
| Plane | Drill | Spot F | Tap | Ream | Assemble |
| Mill | Fit | File | Cut | Lay.O. | |
| A. M. | | | P. M. | | |
| 7 8 | 9 10 | 11 12 | 1 2 | 3 4 | 5 |
| ONLY ONE ITEM ON A CARD | | | | | |

FIG. 166.—Time card to reduce clerical work of machinists.

is still far from satisfactory. The time records can hardly be looked upon as accurate, since they are entirely within the manipulation of the employee. And the time spent in making them out is almost invariably at the expense of production, for the mechanic who would leave his machine running while he grinds a tool will shut it down when he tackles the involved process of making out a time card.

**323.** So far we have been considering methods which originate the time card at the producer. There are also many schemes which relieve the producer of this work and put it on a *specially appointed clerk* or department timekeeper. Aside from those described under mechanical timekeeping, there is the somewhat old-fashioned method of having the department timekeeper make the rounds every night or morning with his time book and enter the records of each man as to the job numbers and length of time on each. This is hardly better than the first method described above, ex-[illegible] that it results in more legible and uniform records. It has [illegible]ame disadvantages, and the men will be required to keep [illegible] anyway providing they work on a variety of work.

The next step in advance is to have the time clerk make more frequent trips with his record book, going through the department every hour or so, and keeping on the lookout for jobs which are finished or nearly so. This takes the burden away from the producer and results in more accurate time, but if the records are kept in book form they will have to be transferred by items to cards before they can be of much use in cost making, on account of the necessity of being able to sort the items in different ways.

**324.** At this point it will be well to speak of the *relation between the timekeeping system and the order system*, for any further advances in methods described will comprise this connection. The more improved shop systems of tracing work and keeping accurate costs require individual orders to be made out, quite often for each operation required. These orders for convenience and simplicity are generally combined into time cards and answer both purposes. This is almost always the case with mechanical timekeeping devices. However, the same principle may apply to keeping time

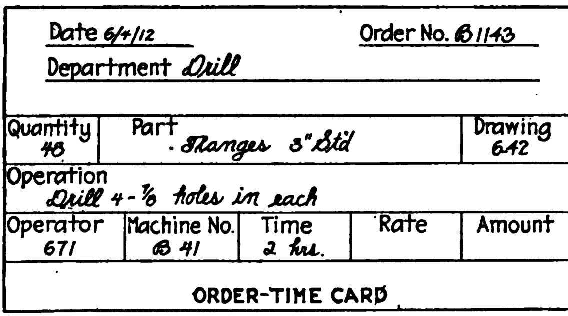


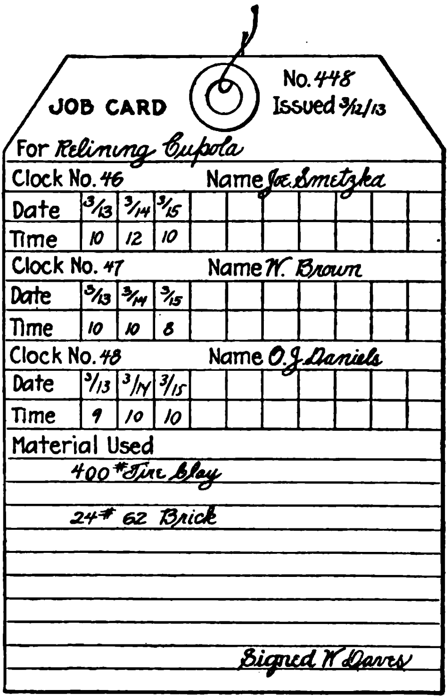

FIG. 167.—An order-time card for one operation.

"by hand," the workman receiving a combined order-time card such as shown in Fig. 167 and filling the time in before returning the completed order.

The difficulty previously mentioned, of time records sometimes covering certain operations on the same piece, and sometimes others, resulting in confusion as to the actual cost of any operation is corrected by placing with the department timekeeper, who usually writes the individual orders and acts as order clerk also, a schedule of operations or route card for each piece. This insures that time records will come in a uniform manner as the mechanic is instructed to secure another card if he is to do more work than is specified on the card. (It must be remembered that we are not yet dealing with strict planning methods and control, but with the common type of foreman control and the ordinary grade of time clerk.)

**325. Cumulative time cards,** or job cards, are sometimes used, as shown in Fig. 168. They are supposed to follow the job from start to finish and to contain a record of all time spent upon it. While

they appear to possess the advantage of simplicity, they are open to many criticisms, first that they frequently become lost, or soiled beyond reading through frequent handling; second that it is impossible to check them unless daily cards are also used, in which case they are not necessary and form a useless expense. They are, however, convenient for special uses, for example, to use in connection with outside jobs or repair jobs where a gang of men are under the supervision of a boss who is capable of making out the job card and assumes responsibility for its accuracy. Material used is frequently indicated on the job card, so that the cost of the completed job may be figured from the one card.



JOB CARD No. 448 Issued 3/12/13

For Relining Cupola

| Clock No. 46 | Name Jos. Smetzka | | |
|---|---|---|---|
| Date | 3/13 | 3/14 | 3/15 |
| Time | 10 | 12 | 10 |
| Clock No. 47 | Name W. Brown | | |
| Date | 3/13 | 3/14 | 3/15 |
| Time | 10 | 10 | 8 |
| Clock No. 48 | Name O. J. Daniels | | |
| Date | 3/13 | 3/14 | 3/15 |
| Time | 9 | 10 | 10 |

Material Used

400 # Fire Clay

24 # 62 Brick

Signed W. Davis

FIG. 168.—A job time card.

Under highly developed management systems, the order-time card may be delivered to the workman with his next job and taken from him when the job is finished, boys being provided to collect finished orders and ring them out on the clock. Such systems generally employ mechanical time recorders. The principle involved is to relieve the workman of all details outside of his actual work.

**326. The following points** should be considered as objective in selecting or *designing a timekeeping system.*

(*a*) To relieve the mechanic of clerical work.

(*b*) To avoid confusion of operations on successive records.

(*c*) To insure accuracy of the time record, and make it difficult to manipulate.

(*d*) To provide a daily balance of all time records against total time.

(e) To insure easy handling of the records for cost purposes, which necessitates but one entry per slip.

**327. Time cards for various compensation systems.** Time cards are adapted in form of construction to the type of system under which they are used. The following are several types used

| | | | | | |
|---|---|---|---|---|---|
| Date 11/14/13 | Machine 4 MB | Part 61 | Operation 30 | Total Quantity 100 | Drawing 6-23 |
| Man's No. 108 | Machine No. B 41 | Man's Name Bill Jones | | | |
| Standard, for High Rate 6 in 10 hrs | | | | | |
| Produced 5 | Time 10 | Rates 44 / 40 | Wages 2.00 | | |
| Instruction Card 441 | Inspected W.M.G. O.K. | | | | |
| Distributed Z | Pay Roll 42 | Noted Adams | | | |

FIG. 169.—Differential piece-work time card.

| | |
|---|---|
| Date 6/4/13 | Part 8B4 |
| Operation No. 6 | Quantity 500 |
| Machine No. 128 | Drawing No. 6-42 |
| Passed by Inspector 128 | Daily Record |
| Rejected { Defective 2, Spoiled 3 } | |
| Time 10 hours | Price 2¢ |
| Amount $ 2.60 | Piece Rate 26¢ <br> Day Rate 20¢ |
| LOT FINISHED | NOT FINISHED |

FIG. 170.—Straight piece work ticket.

for piecework, premium, and differential piecework, etc., Figs. 169, 170, 171. The principles applied to these cards are to show the workman the price, time limit, or task, so that there will be no misunderstanding, and to provide information and space for the cost department to record the cost. With piecework, a time card is often discarded altogether, the piece count or inspector's check taking its place. However, some firms call for time cards

on piecework, to arrive at and record the various rates per hour earned by the workmen.

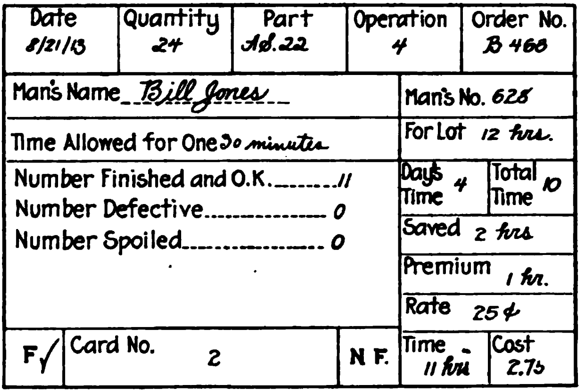



FIG. 171.—Premium time card.

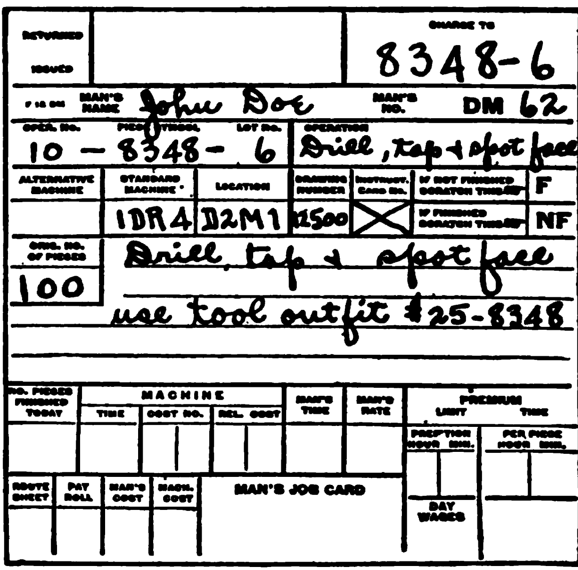



FIG. 172.—Time card for special jobs.

**328. Combination time cards.** There are an endless variety 'hese for every imaginable purpose, and some whose purpose is

difficult to imagine. For example, among the more logical forms is the coupon system, in which the time card is a detachable part of the traveling order tag, and is sent in from various points as the work proceeds. Then there is the combination time and instruction card, as used by the Watertown Arsenal, and shown in Fig. 172.

**329. The combining of too many functions** in one form must be ***guarded against*** as a rule. For example, in the case of the com-

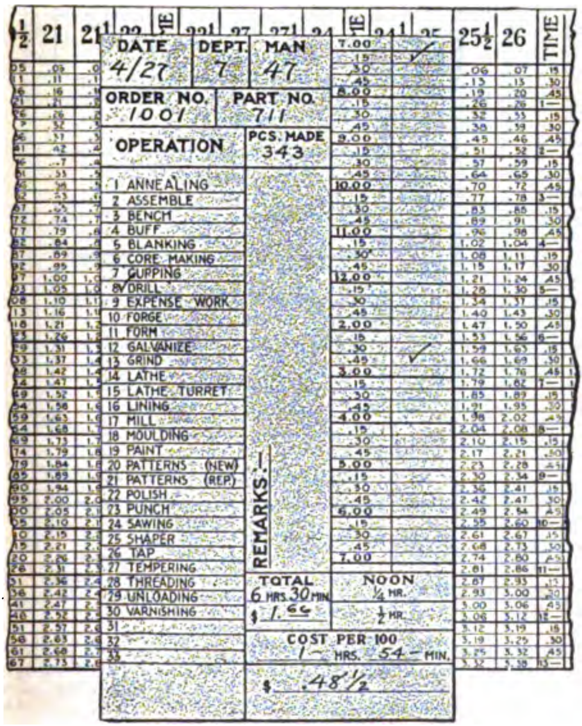



**Fig. 173.—Job time card and how it is placed on computing chart.**

bined time card and instruction card shown in Fig. 172, on infrequently repeated jobs this might be a convenience, but on routine work it would certainly be better to have the instruction card separate, since it would apply for all repetitions of the job. Also where traveling time cards are used, a check must be had daily on the time recorded, as otherwise it is difficult to detect accidental or

intentional omissions which have been made days or weeks before the traveling stubs are entirely returned.

**330. Mechanical timekeeping.** There are various devices on the market, most of them good, for the purpose of keeping time

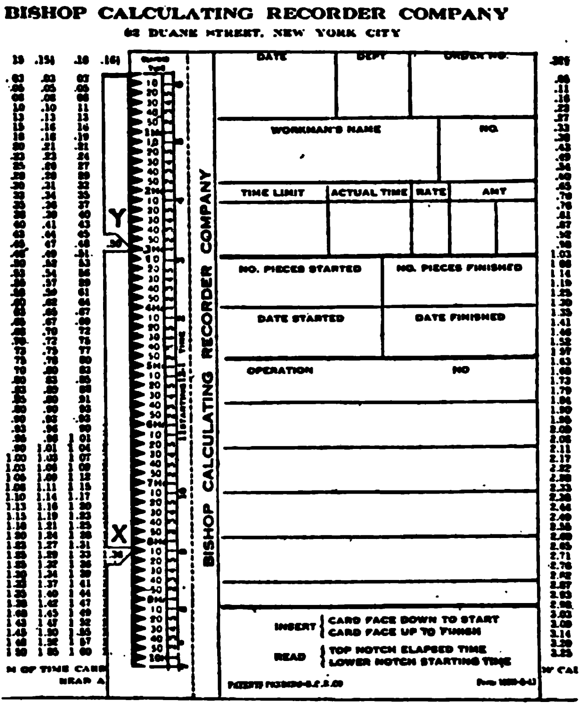



FIG. 174.

records mechanically. The advantage of the use of apparatus of this kind lies in the *moral effect on the employee*, the elimination of clerical work on the part of the producers, legibility of the

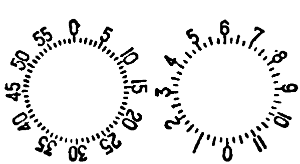


FIG. 175.—Calculagraph first impression.

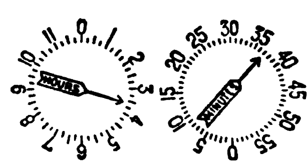
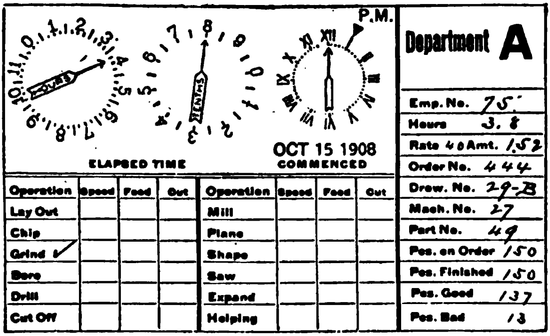
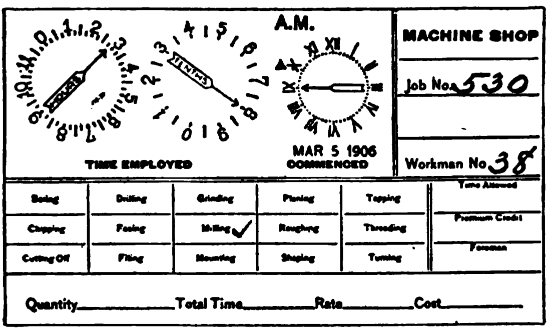


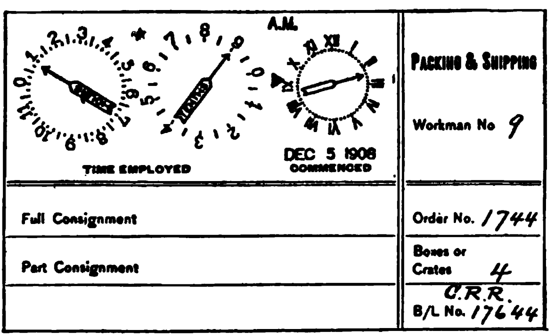

FIG. 176.—Calculagraph second impression.




Department "A" Time Card




Machine Shop Piece-Workers Time Card




Packing and Shipping Time Card

FIG. 177.—Various calculagraph card applications.

records, and reduction of the probability of error. It must be kept in mind, however, that mechanical time recorders will not insure accurate time records. The system of issuing and recalling the order slips must be made to prevent any attempt on the part of the employee to "get the best" of the clock, by retaining one slip while working on another job, or ringing a job "out" before it is finished. The clock itself cannot insure against this practice, although from the literature and advertising of some of their makers the opinion might be formed that they could do so.

Aside from this, these mechanical timekeepers are good things and are coming into more general use every day. The ways and means of using the best known types are described below.

**331. The calculagraph.** This is a timekeeping device which prints the *elapsed* time which has been taken on a job. The printing dies in this machine are in two parts, one carrying a circle of figures and division marks, and the other carrying an arrow. These two dies rotate together, but are capable of independent vertical movement, actuated by two levers which may be called the "starting" and "stopping" levers respectively. When a job to be timed is commenced, the time card is inserted in the calculagraph and the starting lever pulled, which makes an impression of the outer die, as shown in Fig. 175. As time elapses, the dies are turned by the clockwork of the mechanism to which they are attached. When the job is finished, the card is inserted in the machine in the same relative position as before, and the "stopping" lever is pulled, which makes the impression of the arrow in the inner rotating die, within the divided circle already printed on the card. (See Fig. 176.) The position of the arrow indicates the elapsed time in hours and minutes, or in hours and tenths, according to the type of machine.

FIG. 178.—Calculagraph card rack.

The time cards used with this machine, Fig. 177, are of various kinds to suit requirements, an indication of their general nature being shown. As a rule, the time clerk who is stationed in the shop ...ment is in charge of operating the clock, although in some ...e workmen mark their own time with it. It is also extend...ed in connection with telephone and annunciator time-...ystems described in 336-338.

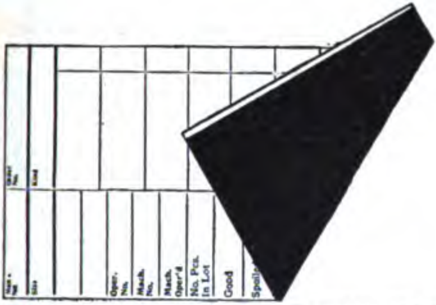



FIG. 182.

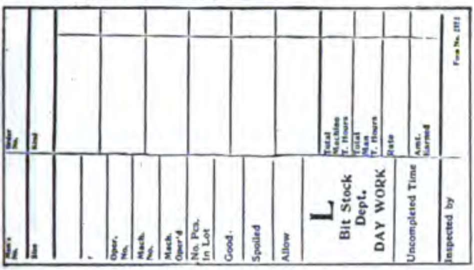



FIG. 181.

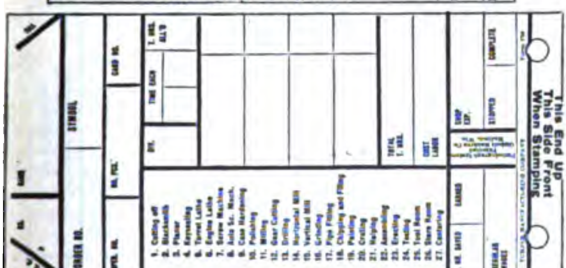



FIG. 180.

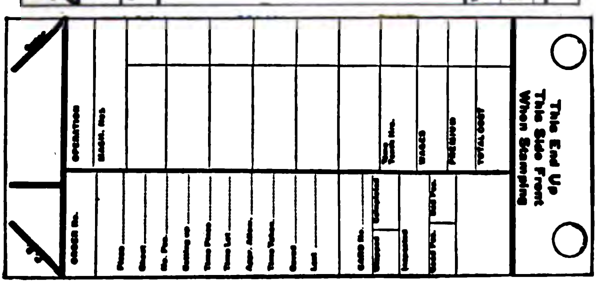



FIG. 179.

Periodograph cards.

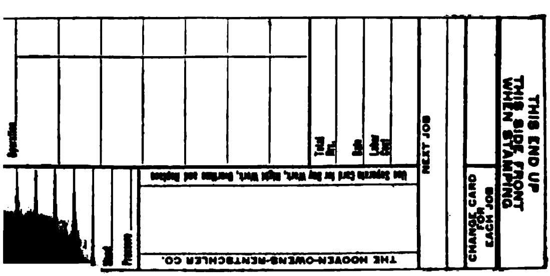



FIG. 183.

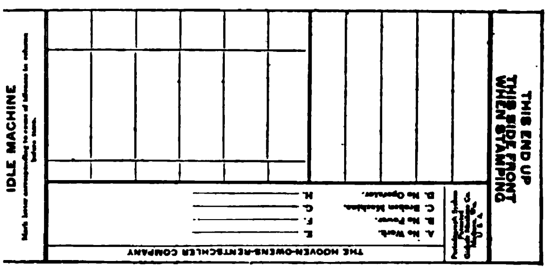



FIG. 184.

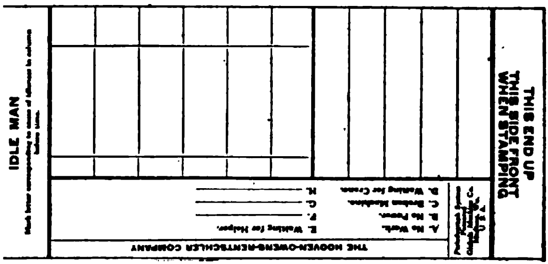



FIG. 185.

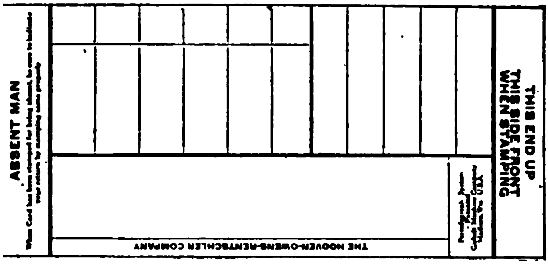


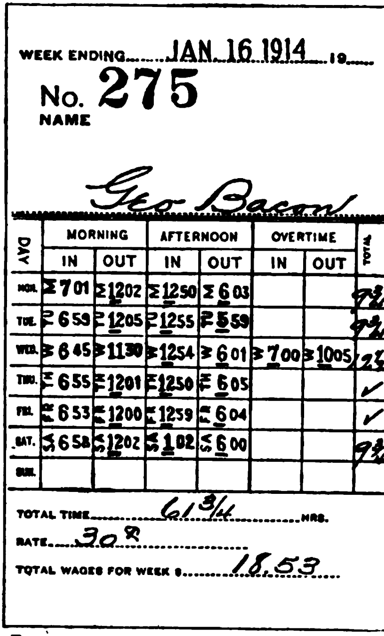

FIG. 186.

The exception principle in time-keeping.

Fig. 178 shows a time-card rack designed by the Calculagraph Co., which is used for several purposes such as assorting various order numbers, for work ahead tickets, and so on. Particular attention is called to the groove which allows the card being grasped by thumb and finger.

**332. The periodograph.** This is a time-recording apparatus originated by the Gisholt Machine Co., of Madison, Wis., which was placed on the market by that company in 1912. A number of time-stamping mechanisms are operated in different departments through the control of a master clock. As the name indicates, periods of time are used instead of the usual minutes, which are either the quarter hour or the tenth of the hour, as desired. On the first morning following the pay period, the clock registers 0000. After the first unit time has expired, the registration will be 0001, increasing one unit at a time. Elapsed time in terms of the unit employed is found by subtracting the lower from the upper record. Forms of periodograph cards are shown in Figs. 179 to 186.

**333. International and similar type recorders.** Recorders of this type are frequently used for cost-keeping purposes, although particularly adapted for registering the daily starting and quitting hours. The International clock for this purpose is provided with a two-color printing ribbon and a mechanism which automatically changes the color of the time record after whistle time, throwing it back again after whistle time at the quitting hour. Thus any late arrivals or early quitters are distinguished by means of red figures. Fig. 187 shows the card used, the red figures being represented in outline to distinguish them from the blue figures which are represented by the full black characters.


WEEK ENDING JAN 16 1914 19

No. 275

NAME

Geo Bacon

| DAY | MORNING IN | MORNING OUT | AFTERNOON IN | AFTERNOON OUT | OVERTIME IN | OVERTIME OUT | TOTAL |
|---|---|---|---|---|---|---|---|
| MON. | 7 01 | 12 02 | 12 50 | 6 03 | | | 9¾ |
| TUE. | 6 59 | 12 05 | 12 55 | 5 59 | | | 9¾ |
| WED. | 6 45 | 11 30 | 12 54 | 6 01 | 7 00 | 10 05 | 2¾ |
| THU. | 6 55 | 12 01 | 12 50 | 6 05 | | | ✓ |
| FRI. | 6 53 | 12 00 | 12 59 | 6 04 | | | ✓ |
| SAT. | 6 58 | 12 02 | 1 02 | 6 00 | | | 9¾ |
| SUN. | | | | | | | |

TOTAL TIME 61¾ HRS.

RATE 30¢

TOTAL WAGES FOR WEEK $ 18.53

FIG. 187.—The International time recorder register card.

The use of this type of clock for detailed operation timekeeping has its disadvantages, possibly the greatest one being the fact that time is recorded in hours and minutes and subtraction is neces-

**Machine No. 287**

Production Order No. 26,432
Stock Order No.
Repair Order No.
Style No. 15C Part No. 287
Job No. Operation 119
Quantity ordered 75
Quantity unfinished from last card
Quantity finished on this card 75
Quantity carried to next card
Estimated time necessary
Rate .67 Time 21½ $14.40
Remarks
15 min. Idle #8

Fig. 188.

**TURN THIS SIDE IN**

Machine Milling
Pay Ending MAR 7 1914
Name Franklin Wright

| DAY | ON | OFF | ON | OFF | ON | OFF | HRS. |
|---|---|---|---|---|---|---|---|
| MON. | | | | | | | |
| TUE. | | | | | | | |
| WED. | | | 1 00 | 6 00 | | | 5 |
| THU. | 8 57 | 12 01 | 12 52 | 6 00 | | | 10 |
| FRI. | 7 00 | 12 00 | 12 40 | 2 45 | | | 6½ |
| SAT. | | | | | | | |
| SUN. | | | | | | | 21½ |

Entered Machine Record W. G. W.
Entered Production Register A. J. C.

• Fig. 189.

**Man No. 527**

Machine Order No.
Repair Order No.
Stock Order No. 9643
Style No. K19 Part No. 187
Job No. 285 Operation 532
298
Crew Chief on this Job is No. 527 302
Numbers of workmen employed on this job 319
Rate 95 Hours 56 $53.20
Expense Burden . . . $33.60
Quantity ordered 50
Quantity unfinished from last card 38
Quantity finished on this card 34
Quantity carried to next card 4
Estimated total time necessary 7 Hrs.
This card started with job [illegible] Finished
This card closes with job [illegible] Finished

Fig. 190.

**TURN THIS SIDE IN**

Department 10
Pay Ending FEB 28 1914
Name Wm. Gordon

| DAY | ON | OFF | ON | OFF | ON | OFF | HRS. |
|---|---|---|---|---|---|---|---|
| MON. | 7 00 | 12 02 | 12 50 | 6 00 | | | 10 |
| TUE. | 8 50 | 12 11 | 12 55 | 6 05 | | | 8½ |
| WED. | 6 58 | 12 00 | 12 49 | 6 07 | 7 00 | 10 00 | 13 |
| THU. | 8 58 | 12 01 | 12 55 | 6 02 | | | 10 |
| FRI. | 9 30 | 12 00 | 12 58 | 6 10 | 6 57 | 9 00 | 9½ |
| SAT. | 7 01 | 12 00 | | | | | 5 |
| SUN. | | | | | | | 56 |

Entered Employe's Record J. T. W.
Entered Production [illegible]ster M. A. S.

Fig. 191.

How the International recorder is used for operation time keeping.

sary. The clock does not record elapsed time. See also Figs. 188 to 191.

**334. Long-distance timekeeping.** Various methods are used to centralize timekeeping in large plants which cover considerable area, and thus reduce to a minimum the number of timekeepers required. The advantages of these systems are reduced cost of labor and centralization of information. On the other hand, there is much to be said in favor of having a timekeeper in the department in which the work is done, especially in plants where perfect routine does not obtain. In such cases the timekeeper, if he is observing, can acquire as much and as valuable information by using his eyes as from the time records, can catch mistakes much more readily, and is in a position to know the details of what he is doing. Among the various means used to facilitate long-distance timekeeping are the following: Cash carriers and pneumatic tube systems, telephones and annunciators. They are described in separate paragraphs.

**335. Cash carrier system of timekeeping.** Where communication of this type is available between departments and a central office, the work tickets may be sent back and forth to the central time office to be stamped by a mechanical recorder before commencing and after finishing the job. It is also convenient to locate the tracing of orders at this point, as the tickets form a source of information as to the movement of work through the various departments. Plants that adopt a scheme of this kind are usually in lines where large lots are put through, and the small time error occasioned by the carrier delivery is not a sufficient error compared with the total length of time on the job to cause uneasiness.

**336. Telephones and timekeeping.** Greater accuracy is secured through the use of the telephone system. The timekeepers are provided with head telephones and are in constant communication with the shop from whom they receive immediate notification of the start and finish of operations. They are usually seated in front of a table provided with racks containing the order slips which they mark or stamp to correspond with the information received. Where the telephone system is used it necessitates a duplicate set of orders or time cards for the time office and the shop, since those in the time office do not circulate to the shop. Telephones must also be provided in sufficient number so that the foremen and gang bosses who notify the office of the movement of work are not required to take too many steps in so doing.

**337. The Cleveland Automatic Machine Co.** makes an ingenious use of telephone timekeeping with a particular intent of using the quick service to check excessive costs before the work is finished. Herbert M. Rich, office manager of that company, describes this feature as follows. (Am. Mach., vol. 32, p. 967.)

"*Collecting time data.* The cost room is connected with every department in the factory by telephone. A time clerk, wearing a head receiver and breast transmitter, sits before a desk, the top of which is divided into compartments, one for each department in the factory. These boxes contain numbered guide cards corresponding to the employee's key number. There is a subdivision in this box and in the forward subdivision the operation cards are filed numerically under their respective departments. These represent

the orders on which work has not yet commenced. As the foreman assigns an order to a workman he takes the order from his file and, turning to the telephone, calls "time" to the exchange operator and is connected with the time clerk. He calls "order 15,855;" the time clerk reaches for the card and calls back to the foreman, "piece 165." This checks both men as having the same order. The foreman then says, "No. 216, first operation, last job complete." The time clerk enters No. 216 on this card and puts down the time and places the card behind guide card No. 216 and takes out the card he had been working on previously, enters the elapsed time and puts the card aside in a "finished operation" box.

"*Checking operation time.* Boys in the factory shortly commence reporting by 'phone, "No. 216 produced four pieces." His operation card is referred to and this shows when he commenced and it is seen how long he has taken to perform this operation on the four pieces. This is compared with the estimated time shown on the same card, and right here is the kernel in the nut; if he is not coming up to the estimate, operation report, Fig. 192, is filled out, showing the estimated time and actual performance, and sent to the superintendent. The matter is taken up at once and, in practically every

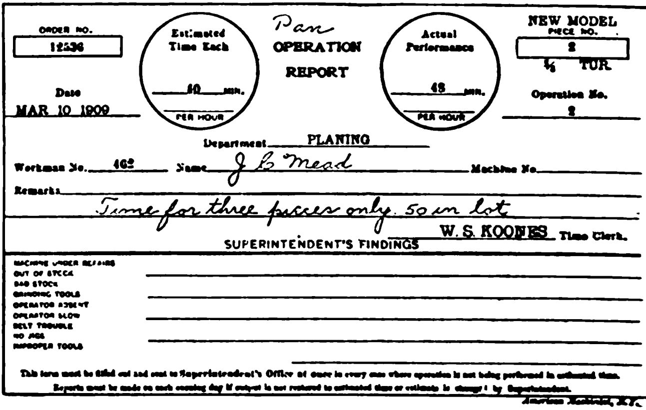

ORDER NO.
12536
Estimated Time Each
40 MIN.
PER HOUR
Pan
OPERATION REPORT
Actual Performance
48 MIN.
PER HOUR
NEW MODEL
PIECE NO.
2
½ TUR
Date
MAR 10 1909
Operation No.
2
Department PLANING
Workman No. 462 Name J B Mead Machine No.
Remarks
Time for three pieces only. 50 in lot.
W. S. KOONES Time Clerk.
SUPERINTENDENT'S FINDINGS
MACHINE UNDER REPAIRS
OUT OF STOCK
BAD STOCK
GRINDING TOOLS
OPERATOR ABSENT
OPERATOR SLOW
BELT TROUBLE
NO JIGS
IMPROPER TOOLS

FIG. 192.—The operation report.

case, it is possible to get the estimated time on the remaining part of the lot. A lot of, say, 50 pieces might have cost $12 or $15 if allowed to go unwatched but, by following it up at the moment, the lot went through with a cost of $3 or $4, a clear saving in labor of $8 to $10. No cost system that allowed days or weeks to elapse could possibly obtain these results."

**338. Annunciator system in timekeeping.** Several methods are in use. One of them provides a push button for each operator, the drop on the annunciator board being numbered to correspond with his clock number. When a workman changes jobs, he presses a button and goes ahead on the new job; the time clerk at the annunciator board makes the finishing and starting time notation and then sends a messenger boy out to get the number of the new job and other data which are required, but which may be obtained at leisure without impairing the accuracy of the time record.

In other cases, a group of men are assigned to each push button, the number being usually 10. Clips are provided for each group, so

that the messenger boy may find the proper memorandum for all calls sent in.

The Calculagraph Co. state that one firm which uses this system in connection with their machine, obtains its time records at an average labor cost of less than 1 cent per man per day. (See Fig. 193.)

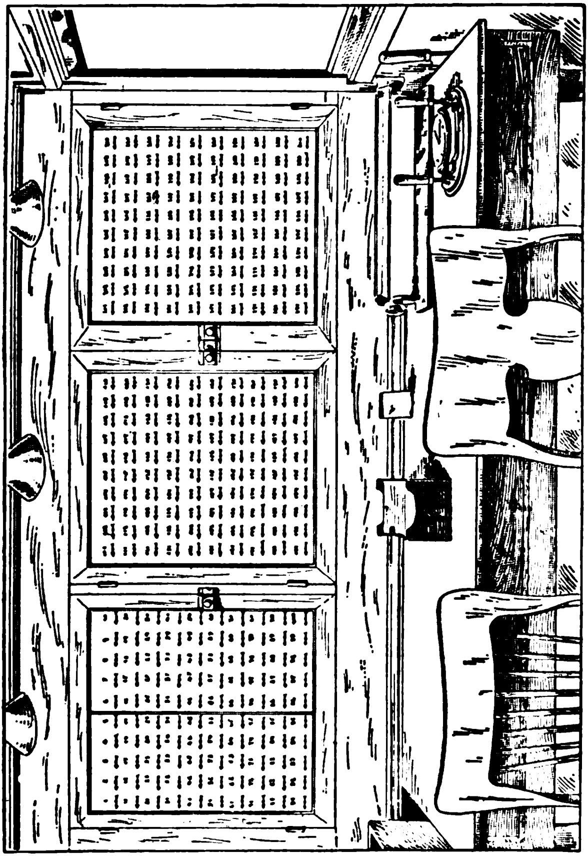


FIG. 193.—Annunciator system of timekeeping.

**339. The exception principle in timekeeping.** Under this method great stress is laid upon the losses occasioned through idle men and machines and upon the definite recording of such losses. These may be classified in various ways. For example: as idle machines, idle men, and again further subdivided as to the cause,

such as lack of material, tool broken down, lack of working instructions, lack of small tools, and so on. The periodograph cards which are shown in Figs. 183 to 186 illustrate the application of the exception principle at the Hooven, Owens and Rentschler shops at Hamilton, Ohio. At the Fairbanks, Morse plant at Beloit, Wis., the recording of idle time is made still more apparent by the use of colored signals which are hung from the machine shifters. For example, a red signal might indicate that the operator had no work, or was short of material; a yellow signal would indicate that the machine was under repair. A definite advantage of this method of signals is that the man in charge can see at a glance the operating conditions of the machines in the department.

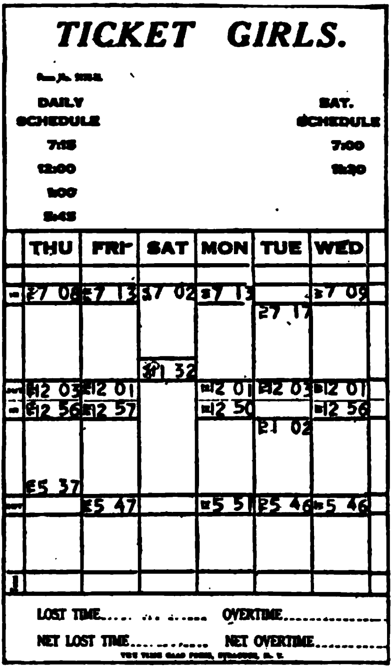



Fig. 194.—Stromberg "in and out" cards.

**340. The Stromberg clock system.** The Stromberg Electric Co., Chicago, in addition to their other clock systems, supply a master clock controlling a number of departmental time stamps for the purpose of recording the time on individual jobs as well as the in and out time of the operatives. Fig. 194 indicates how the in and out time is recorded by the Stromberg system and how any discrepancies in arriving or departing time are emphasized by their position upon the time card. Fig. 195 indicates or shows the application of this time stamp to operation orders. It will be noted that the daily time card, which forms the record of a day's performance for each operator, is perforated so that the records of individual jobs may be distributed or sorted irrespective of a man's number. The time recorder is automatically arranged to conform to the working hours of the plant where it is used. Each morning at the regular starting hour the machine will record 0.0; the type face of the time stamp is then changed each minute through the action of the master clock. Variations from this method are used where it is not required to keep time to such a fine degree, which case the tenth of an hour is commonly used as a unit.

Where this system is adopted it is necessary to provide additional time stamps for operation recording and for in and out recording. The elapsed time for any operation is found by subtracting the lower from the upper time record.

**341. Continuous operation recorders.** Electrically operated devices are on the market for the purpose of indicating the length of time that machines remain idle, the length of time under cut, and so on. The principle of operation of these machines is an attachment at the machine which is connected with the driving means, which actuates a pencil in a recorder which may be at any distance, making a record that resembles an elongated Morse telegraph code. For example:

*a* *b* *c* *d* *e* *f* *g*.

In the above record, the line *a* represents the first cutting operation, which stopped at *b* as indicated by the space, resumed again at *c*, stopped at *d*, resumed for a moment at *e*, stopped at *f* and again resumed for the last cut at *g*. The length of the record is made in terms of time, corresponding to hours and tenths of hours, therefore the total length of the record is a measure of the length of time required to do the work. Each job is supposed to have a certain characteristic, that is, definite relations between the stops and starts and the length of each. Therefore any discrepancy between the record obtained and the standard will be subject for inquiry.

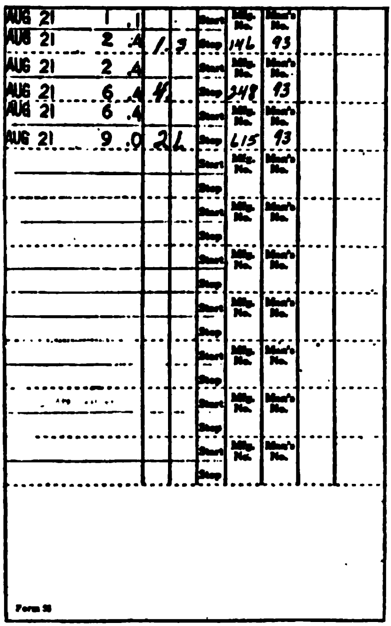


FIG. 195.—Stromberg operation time cards.

The use of a system of this kind presupposes an exact knowledge of what time is required and should be taken, and with this all important information there would seem to be infinitely simple ways to insure that the standard is reached. However, for machines that work on one or two operations continuously, the scheme is more feasible.

**342. Production counters.** Counting machines are attached to machines whose productivity is in direct proportion to the number

of revolutions or strokes made, in order that a gage may be had upon their efficiency. For example, punching presses, forging machines, and so on, are easily kept track of by this method. The *output is checked against the number of strokes*, and this again against the normal number of strokes per minute, giving indications both as to whether the machine is allowed to run idle and whether the operator has run it as continuously as possible. Where this system is used and presses are kept continuously on certain classes of work, the exception principle is used with regard to the timekeeping. In other words, time items are not made out for the productive time, but for the shut-downs. An example of this is shown in Fig. 196, which also illustrates the use of a production counter.

Machine No. 141　　Date 6/12/14
Operator Schmetzka　　No. 628
Working on Blanks for #10 screw covers
Order No. 6821

| Operator's Report | |
|---|---|
| Reason for Shutdown | Time |
| Testing Dies | 30 min |
| Fix Belt | 15 " |
| Waiting for Material | 30 " |
| | |
| | |
| | |
| | |

Total Delays 1 hr. 15 min
Total Productive Time 8 hr. 45 min
Rated Strokes per Minute 20
Maximum Output 10,500
Actual Output 3,125
Efficiency 30%
Counter Reading 177648
Last Counter Reading 174308
Actual Strokes 3340　　Per Minute 6.35

FIG. 196.—Production counter time card.

## WORKING HOURS

**343. Working hours.** The practice in the matter of working hours varies widely, not only in the total number worked per week, but in the arrangement of the daily schedule. For example, a great many firms make a practice of closing their plants on Saturday afternoons all the year round, while others do so only during the summer season. Some allow ½ hour for the lunch period, others the full hour. Where the majority of workmen carry their lunches the shorter period is probably desirable, since it allows them to get home earlier and also cuts down the lighting expense of the plant during the dark months. The arrangement of hours from the point of view of making the most of daylight is important, and is one argument against shutting down on Saturday afternoons the year round.

In some plants, working hours as far as details such as starting time, lunch period, and so on are concerned are decided by submitting to vote of employees, which eliminates discontent regarding them.

Tables of working schedules are shown, figuring both with and

without the Saturday half holiday, and with lunch periods of ½, ¾ and 1 hour. These are given for 48, 50, 54, and 60 hours a week. Attention has been paid in making these schedules to make the most of the daylight hours, and to balance the periods before and after lunch. With respect to this last condition, it would probably be better to make the morning period a longer one than the afternoon, as most people are capable of their best efforts during this period.

**344. Other lunch periods.** In foreign countries it is the practice to allow a morning lunch period between starting and noon hour. Sometimes in this country a definite time has come to be looked upon as for the morning lunch, although not necessarily officially recognized. It is a bad scheme to prohibit the eating of morning lunches, as any one who has had experience at hard physical labor will testify that they are quite necessary. The manufacturer would hardly prohibit the fireman from throwing coal on the fire when needed, and should not object to his employees replenishing their energy supply in this manner, especially since they furnish the fuel. The use of alcoholic drinks should of course be prohibited within the shop, and discouraged during the noon lunch, although unfortunately most manufacturing plants are surrounded by saloons with free-lunch counters. No matter what a man's opinion may be as to the liquor question, it is indisputable that even moderate quantities taken at noon will result in a more or less sleepy and indolent feeling whch is not productive of the best results. This is possibly a strong reason for the establishment of lunch rooms by the company, outside of the reasons

**Without Saturday Half Holiday, ½ Hour Lunch Period**

| | 48 hours | | | | 50 hours | | | | 52 hours | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start<br>Quit | 7.00<br>12.00 } 5 | 7.30<br>12.00 } 4.30 | 8.00<br>12.00 } 4 | 8.00<br>12.30 } 4.30 | 7.00<br>12.00 } 5 | 7.20<br>12.00 } 4.40 | 7.40<br>12.00 } 4.20 | 8.00<br>12.30 } 4.30 | 7.00<br>12.00 } 5 | 7.20<br>12.00 } 4.40 | 7.30<br>12.00 } 4.30 | 7.40<br>12.00 } 4.20 |
| Start<br>Quit | 12.30<br>3.30 } 3 | 12.30<br>4.00 } 3.30 | 12.30<br>4.30 } 4 | 1.00<br>4.30 } 3.30 | 12.30<br>3.50 } 3.20 | 12.30<br>4.10 } 3.40 | 12.30<br>4.30 } 4 | 1.00<br>4.50 } 3.40 | 12.30<br>4.10 } 3.40 | 12.30<br>4.30 } 4 | 12.30<br>4.40 } 4.1C | 12.30<br>4.50 } 4.20 |
| | **54 hours** | | | | **56 hours** | | | | **60 hours** | | | |
| Start<br>Quit | 7.00<br>12.00 } 5 | 7.10<br>12.00 } 4.50 | 7.20<br>12.00 } 4.40 | 7.30<br>12.00 } 4.30 | 7.00<br>12.00 } 5 | 7.10<br>12.00 } 4.50 | 7.20<br>12.00 } 4.40 | 7.30<br>12.30 } 5 | 7.00<br>12.00 } 5 | 7.10<br>12.30 } 5.20 | 7.15<br>12.30 } 5.15 | 7.20<br>12.30 } 5.10 |
| Start<br>Quit | 12.30<br>4.30 } 4 | 12.30<br>4.40 } 4.10 | 12.30<br>4.50 } 4.20 | 12.30<br>5.00 } 4.30 | 12.30<br>4.50 } 4.20 | 12.30<br>5.00 } 4.30 | 12.30<br>5.10 } 4.40 | 1.00<br>5.20 } 4.20 | 12.30<br>5.30 } 5 | 1.00<br>5.40 } 4.40 | 1.00<br>5.45 } 4.45 | 1.00<br>5.50 } 4.50 |

**Saturday Half Holiday, ¾ Hour Lunch Period**

| | 48 hours | | | |
|---|---|---|---|---|
| Start / Quit | 7.00 / 12.00 } 5 | 7.30 / 12.00 } 4.30 | 8.00 / 12.00 } 4 | 8.00 / 12.30 } 4.30 |
| Start / Quit | 12.45 / 4.21 } 3.36 | 12.45 / 4.57 } 4.12 | 12.45 / 5.33 } 4.48 | 1.15 / 5.27 } 4.12 |
| Saturdays | | | | |
| Start / Quit | 7.00 / 12.00 } 5 | 7.30 / 12.00 } 4.30 | 8.00 / 12.00 } 4 | 8.00 / 12.30 } 4.30 |

| | 50 hours | | | |
|---|---|---|---|---|
| Start / Quit | 7.00 / 12.00 } 5 | 7.20 / 12.00 } 4.40 | 7.40 / 12.00 } 4.20 | 8.00 / 12.30 } 4.30 |
| Start / Quit | 12.45 / 4.45 } 4 | 12.45 / 5.09 } 4.24 | 12.45 / 5.33 } 4.48 | 1.15 / 5.51 } 4.36 |
| Saturdays | | | | |
| Start / Quit | 7.00 / 12.00 } 5 | 7.20 / 12.00 } 4.40 | 7.40 / 12.00 } 4.20 | 8.00 / 12.30 } 4.30 |

| | 52 hours | | | |
|---|---|---|---|---|
| Start / Quit | 7.00 / 12.00 } 5 | 7.20 / 12.00 } 4.40 | 7.30 / 12.00 } 4.30 | 7.40 / 12.00 } 4.20 |
| Start / Quit | 12.45 / 5.09 } 4.24 | 12.45 / 5.33 } 4.48 | 12.45 / 5.45 } 5 | 12.45 / 5.57 } 5.12 |
| Saturdays | | | | |
| Start / Quit | 7.00 / 12.00 } 5 | 7.20 / 12.00 } 4.40 | 7.30 / 12.00 } 4.30 | 7.40 / 12.00 } 4.20 |

| | 54 hours | | |
|---|---|---|---|
| Start / Quit | 7.00 / 12.00 } 5 | 7.10 / 12.00 } 4.50 | 7.20 / 12.00 } 4.40 |
| Start / Quit | 12.45 / 5.33 } 4.48 | 12.45 / 5.45 } 5 | 12.45 / 5.57 } 5.12 |
| Saturdays | | | |
| Start / Quit | 7.00 / 12.00 } 5 | 7.10 / 12.00 } 4.50 | 7.20 / 12.00 } 4.40 |

| | 56 hours | | |
|---|---|---|---|
| Start / Quit | 7.00 / 12.00 } 5 | 7.10 / 12.00 } 4.50 | 6.45 / 12.00 } 5.05 |
| Start / Quit | 12.45 / 5.57 } 5.12 | 12.45 / 6.09 } 5.24 | 12.45 / 5.54 } 5.09 |
| Saturdays | | | |
| Start / Quit | 7.00 / 12.00 } 5 | 7.10 / 12.00 } 4.50 | 6.45 / 12.00 } 5.15 |

| | 60 hours | | |
|---|---|---|---|
| Start / Quit | 7.00 / 12.00 } 5 | 6.45 / 12.00 } 5.15 | 6.30 / 12.00 } 5.30 |
| Start / Quit | 12.45 / 6.45 } 6 | 12.45 / 6.30 } 5.45 | 12.45 / 6.15 } 5.30 |
| Saturdays | | | |
| Start / Quit | 7.00 / 12.00 } 5 | 6.45 / 12.00 } 5.15 | 6.30 / 12.00 } 5.30 |

**Saturday Half Holiday, 1 Hour Lunch Period**

| 48 hours | | | | |
|---|---|---|---|---|
| Start–Quit | 7.00–12.00: 5 | 7.30–12.00: 4.30 | 8.00–12.00: 4 | 8.00–12.30: 4.30 |
| Start–Quit | 1.00–4.36: 3.36 | 1.00–5.12: 4.12 | 1.00–5.48: 4.48 | 1.30–5.42: 4.12 |
| **Saturdays** | | | | |
| Start–Quit | 7.00–12.00: 5 | 7.30–12.00: 4.30 | 8.00–12.00: 4 | 8.00–12.30: 4.30 |

| 50 hours | | | | |
|---|---|---|---|---|
| Start–Quit | 7.00–12.00: 5 | 7.20–12.00: 4.40 | 7.40–12.00: 4.30 | 8.00–12.30: 4.30 |
| Start–Quit | 1.00–5.00: 4 | 1.00–5.24: 4.24 | 1.00–5.48: 4.48 | 1.30–6.06: 4.36 |
| **Saturdays** | | | | |
| Start–Quit | 7.00–12.00: 5 | 7.20–12.00: 4.40 | 7.40–12.00: 4.30 | 8.00–12.30: 4.30 |

| 52 hours | | | |
|---|---|---|---|
| Start–Quit | 7.00–12.00: 5 | 7.20–12.00: 4.40 | 7.30–12.00: 4.30 |
| Start–Quit | 1.00–5.24: 4.24 | 1.00–5.48: 4.48 | 1.00–6.00: 5 |
| **Saturdays** | | | |
| Start–Quit | 7.00–12.00: 5 | 7.20–12.00: 4.40 | 7.30–12.00: 4.30 |

| 54 hours | | | |
|---|---|---|---|
| Start–Quit | 7.00–12.00: 5 | 7.10–12.00: 4.50 | 6.50–12.00: 5 |
| Start–Quit | 1.00–5.48: 4.48 | 1.00–6.00: 5 | 1.00–5.38: 4.38 |
| **Saturdays** | | | |
| Start–Quit | 7.00–12.00: 5 | 7.10–12.00: 4.50 | 6.50–12.00: 5 |

Working more than 54 hr. per week, the noon period would seldom exceed 45 min.

from a welfare point of view. It is quite possible that proper feeding has a sufficiently important bearing on energy to make it a paying proposition to take up, even though the lunch stand must be run at a loss in order to make it attractive. The shortening of the noon hour as much as possible also tends to prevent the reduction in efficiency through improperly used time.

In some plants, mostly European, iced tea and other non-alcoholic beverages are offered at low cost to combat the efficiency-reducing consumption of beer.

**345. Registering of absentees.** Absences in the shop constitute such a large drawback to production that it is well to have a definite scheme for keeping track of the absentees, and a policy of reducing their number. With any of the modern registering systems, or even the older fashioned in and out checks, it is an easy matter to find out who is absent. The next step is to make use of this information. An absence should not be allowed to pass by without an explanation. The general plan of having each employee who is sick have a member of his family telephone to the time office should be adopted. Understanding may be had with the telephone company to reverse charges on messages of this kind, so that it is not a burden to the employee who is usually deprived of his day's pay when absent. Neither is it an expense on the shop, which undoubtedly has unlimited phone service. If it is insisted upon that this practice is followed and a record kept of the reasons given in each case, it will soon develop who the chronic invalids are, and whether their illness is coincident with ball games on the home grounds.

A list of the absentees for each department should be handed to the department foreman early each morning, together with the reasons for absence and the probable duration, so that work may be planned. Especially in case of machine operators should absences be strictly followed up, even to the extent of sending someone to the employee's home, for an idle machine is one of the quickest profit reducers. There are certain excusable reasons for absence, such as sickness, death of relations, weddings, and an occasional holiday or lodge outing cannot be denied, but there should not be too great a difference between the number of days off of different individuals, except in the case of a prolonged illness. A statement should be made out each month and handed to the superintendent, giving the number of days absent for each man. Chronic invalids, or vacationists, may be given a heart-to-heart talk and placed on suspended sentence. Systematic efforts along these lines will not fail to improve the attendance record and increase production.

**346. Incentives to attend.** It is sometimes found, especially when jobs are plentiful, that employees make a practice of taking a day off quite regularly. If help is scarce, as it is likely to be under these circumstances, it is a problem as to how to correct the evil without driving the employee to another job. Some firms adopt [illegible] additional bonus for regularity in attendance. This is usually [illegible]d on a percentage of the weekly earnings. The question as [illegible] much this should be is not difficult to estimate from the point

of view as to what it is worth. For example, assuming that the profits for the year be divided by the number of employees, a figure will be obtained representing the average profit earning capacity per man. This may be still further reduced to an average per man per day or even per hour. The total amount of the bonus to be divided should be figured from a study of the loss of earnings or profits represented by previous years absences, and whatever portion of this total the management sees fit may be used as the bonus fund.

The bonus is more effective if applied or offered in the form of prizes in the various departments for the best attendance records, since if it is offered in this way the amount offered is sufficient to act as an inducement, whereas if it is applied as a general premium on attendance, the per capita sum available will not be enough to make an impression.

**347. Registering and handling "Lates."** This is something that for best results requires considerably more thought than is usually given to it. The common practice is to make a ruling to the effect that a late employee is docked a certain amount, usually not less than ½ hour. Sometimes the shop doors are closed sharply at whistle time, and opened again 1 hour later to admit those who were late at first.

From the standpoint of production and profits, it is certainly "better late than never," and it is a question as to whether it pays to shut a productive machine down for 58 minutes because its operator is 2 minutes late. On the other hand, it is essential to foster promptness, as otherwise the daily routine would be much disturbed.

**348. This question must also be considered from another point of view.** Take the case of the employee who is conscientious and faithful and whose record is good. For some unpreventable cause he happens to be a few minutes late some morning. Very likely he is engaged on an important job and knows that his foreman needs him. He is allowed to go to work under the first plan mentioned, but on pay day finds a half hour taken out of his time. The company has secured 20 or 30 minutes work from this man for nothing, but as a rule it has paid dearly in the decrease of loyalty which will naturally come through such a small action. Possibly this same workman has been in the habit of getting to the shop 10 or 15 minutes before whistle time.

What is required to handle these things intelligently is more judgment than system. The head timekeeper should be a man of broad gage and discrimination and should be allowed a certain leeway in the decision of such things. From his daily work he will know who are the habitual lates, and also those who make a practice of running in just before the whistle blows, and when such individuals are late he will apply the given penalties. On the other hand, by using judgment in other cases, such as the one described, he can save his company money and add a great deal to the feeling of esteem in which it is held. A good man regards his work and his company as something personal and not a machine, and is often willing to do something for it that he is not really paid for. We do

not encourage this spirit when we apply hard and fast rules without discrimination. *Loyalty must be reciprocal*, and we cannot expect it from the men unless we extend it to them.

The objection may be raised that such a plan would result in favoritism on the part of the timekeeper. This is easily prevented by requiring a list handed in daily of all exceptions made to the rule and the reason for them. From this it will be easy to detect any undue repetition of such favors to any one person.

**349. Various schemes** are used *to indicate lateness* on the mechanical time-registering devices. Possibly the most effective is one which prints late arrival's time in red. The other records are made in blue or black, and the ribbon in the clock changes position and color at whistle time. This method saves considerable time on the part of the timekeepers in looking over the cards, as one which is printed in blue or black throughout will indicate full time. None of these schemes are without means of circumvention, however. In the case of the bi-colored clock, for example, a Hungarian foundry laborer managed to get around it and draw full time for several weeks by placing a sheet of blue carbon paper over his card when registering.

**350. A list of lates** should be prepared by the timekeeper at regular periods and handed to the management, also from time to time a record of the employees by number showing the total amount of lateness during a given period.

Sometimes the position of the time card in the rack indicates the lates and absentees. Another scheme is used by the Hall Printing Press Co., as described by Philip W. Hall. A board is used on which are recorded the names of all the employees. Three holes are made in the board opposite each man's name, and the position of a pin or button placed in these indicates whether the man is in, out or late.

**351. Employment records.** Most concerns make it a practice to keep records of their employees, but the particulars which are recorded differ considerably. The purpose may be simply as a record of hiring date, name and address, with space for the discharge or quitting, or it may be a quite complex record of individual characteristics and traits. Among the items which may be recorded are the following: Name; nationality; age; address; previous employment (usually going back at least 5 years); reasons for leaving last place; date and time of starting work; department in which placed; machines or classes of work which employee is able to handle; work which he likes best; physical characteristics; weight, height, general health. Going one step farther, and making use of the record as an efficiency indication, with the view of obtaining from it information which will aid in making changes of rate, in connection with the time records: Punctuality, willingness, skill, adaptability, ideas, directive capacity. The first item, punctuality, may be easily measured by the daily time clock records, the remaining are arrived at by study of the individual and are marked according to some scale, such as "Very Good," "Good," "Fair," "Poor" and "Very Poor." For brevity, numbers may represent these words. The capacity

of the various employees is an important thing to know, quite as much so as that of the various machines that they operate. Systematic efforts to obtain this information will necessitate a study of the individuals which in itself will be worth the expenditure of time and energy. Foremen's reports help in determining the various values, although the prejudice of the foreman often warps his opinion. *Reports from the time and cost office* will throw additional light on the matter. For example, exceptionally good or exceptionally bad time records when frequently repeated will act as guides, although one or two are of little value.

It is hardly necessary to say that records which describe the efficiency of the workman should be kept in cipher, or else under lock and key, so that irresponsible clerks may not carry the information to their friends in the shop.

**352. Available employee record.** This is somewhat similar in character to the first part of the employment record described above, stating name, address and previous record of employment. In fact the same form is often used, and transferred to an active file when the man is hired.

**353. Record of former employees.** This is of value in two ways: first, when the same individual applies for re-engagement; secondly, when others ask for records with the view of employing the individual. The same form may be conveniently used, transferring the sheet or card to a third file when the man quits or is discharged.

## PAY-ROLL METHODS

**354. Pay-roll compilation.** The pay-roll may be simply a weekly account of each man's hours, rate and wages, compiled for the sole purpose of finding out how much to put in each pay envelope, or it may be a complete and classified analysis of labor expense as well. The former would necessitate simply a list of employees' numbers and rates, usually kept in book form, with columns left blank for the number of hours worked and the wage totals. The following illustrates the simple pay-roll method:

| | | | Week ending 7/13 | | Week ending 7/20 | |
|---|---|---|---|---|---|---|
| Man's No. | Name | Rate | Hours | Wages | Hours | Wages |
| 1 | John Smith | 20 cents | 50 | $10.00 | .. | ....... |
| 2 | William Jones | 18 cents | 54 | 9.72 | .. | ....... |

The next step comes when these numbers are divided into groups, representing the divisions by departments or gangs. This does not require much labor, but gives the management considerably more information. A still further step divides each man's pay into various accounts, among which may be the following:

Productive Work: This may be still further sub-divided according to the purposes of the management into stock and special orders, regular time and overtime, or numberless other ways.

Non-productive Work: Classified into as many accounts as there are varieties or groups to be segregated. Among them, non-productive work by producers, such as labor on defectives, time on spoiled work, repairs to machines, shop tools, etc., etc.

A pay roll-form of the last-mentioned type is shown in Fig. 197. It will be seen that there are a great many accounts on this sheet, which is in ledger form, but the compilation of the figures is done by a girl clerk in less than 1 day, for a force of 800 employees. That is, the compilation of the pay-roll itself is made in this length of time, from time cards which have been already rated and extended.

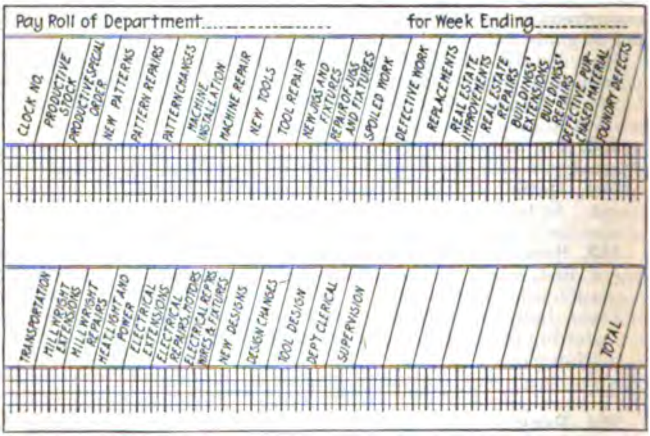



FIG. 197.—A classified pay-roll.

**355. The pay-roll may be made up from the clock register card** which shows the total number of hours that each man works each day, or it may be made up from the individual time slips which come in from the shop. The former method would probably be adopted with the simpler type of pay-roll first mentioned, but the time-slip system would have to be used when a distributed pay-roll is desired. The method of doing this is as follows: First, the daily time slips, which come from the various departments, must be rated and extended, and the distribution or account numbers marked upon them. It is understood that these time slips are made out for individual jobs or operations, so that they may be sorted in various ways, and for this purpose but one entry must appear on any one slip. The entries will comprise date, man's clock number, work done, time taken to do it, and order number. The slips, having been sorted as to man's number, rated and extended, are checked against the clock record cards to see that the man has accounted for full time. (This is not necessary when using the clock system of timekeeping on individual jobs.) They are then sorted as to distribution accounts and the items entered into the proper columns. This completes the work of the pay-roll clerk, except to balance the total so obtained against the total obtained by multiplying each man's total hours by his rate and adding the

individual amounts to secure a checking figure. Usually before this distribution is done, the slips have been sorted as to order number and the items entered upon the cost-of-order cards, but this has nothing to do with the pay-roll itself.

After the envelopes are prepared with the names of the employees and their numbers, the amounts are written upon them from the total column of the pay ledger, and the grand total as shown upon the envelopes when completed is checked against the ledger total.

Sometimes the pay-roll ledger sheet is replaced by a card form, as shown in Fig. 198, and the distribution made on sheets as in Fig. 199. In fact, hardly any two shops use the same form for pay-roll work, although the methods used in compiling the pay-roll are usually as described.

**356. Pay envelopes** also exist in numberless variety, ranging from those which are covered with advertising matter relative to the goods of the local merchants who furnish them free of charge, to the transparent envelope illustrated in Fig. 200, which is used by the Westinghouse Co. This is for the purpose of avoiding disputes, and since the pay is always in specie, it is easy for the employee by shaking the envelope a trifle to be able to see the amount contained before it is opened. If there is a

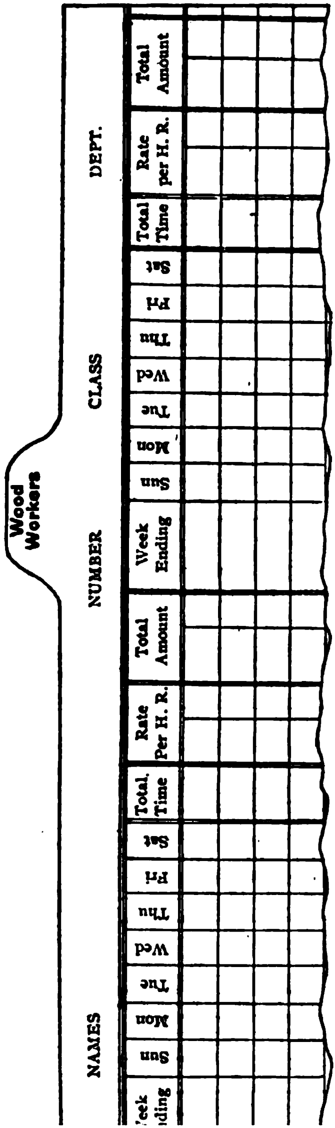



FIG. 198.—Card pay-roll form.

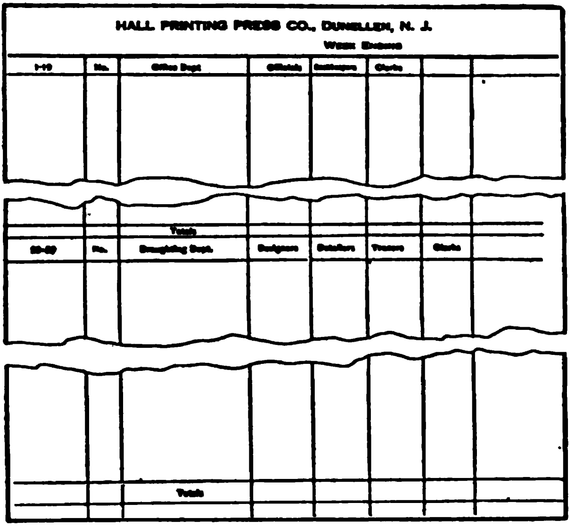
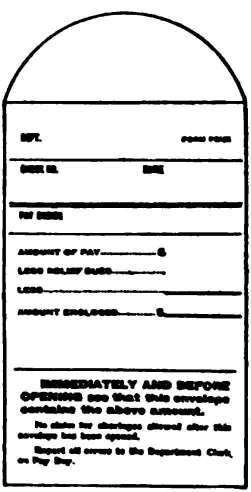



FIG. 199.—Distribution sheet.

shortage claimed, the envelope must be returned intact. Another ingenious form of envelope is shown in Fig. 201, which is used by the Hall Printing Press Co. On the left-hand side, the man's name and number are written, and on the right-hand side is the amount due in wages. A perforation separates these two items, the envelopes being torn open on the perforation. Once they are opened, no one can tell how much was paid to any one man, as all the stub ends are similar.

**357. Mechanical helps in pay-roll compilation.** There are me-




200.—Transparent envelope.

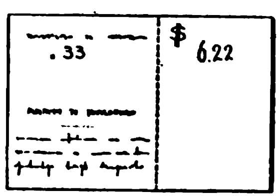



FIG. 201.—Perforated envelope.

chanical devices, charts, and the like which multiply rate of pay by hours. The saving effected by these is a question, since the average pay-roll clerk becomes so accustomed to the various combinations that he or she is able to write the wage amount almost instantly. The adding machine is of value in pay-roll work, and some are on the market which will add a number of independent accounts or columns, and which are useful in totaling distributed pay-rolls. The adding typewriter has been used to print the amounts upon pay envelopes and carry forward the totals. The addressograph is frequently used for the purpose of printing names and numbers on envelopes, doing this in a fraction of the time required by hand. In fact the old-fashioned "paymaster" is fast becoming obsolete and the making of a pay-roll is becoming a matter of mechanical routine.

**358. Pay voucher and receipts.** Practice is divided in the matter of requiring a receipt from the employee for his wages. When this is not done, it is customary to have a checker accompany the paymaster and check off the individual's name or number as he receives the envelope. Where the receipt is required it is sometimes a ticket enclosed within the envelope, stating the man's name, number, and amount received, and having a space for his signature. To avoid loss of time the employees are allowed to deposit the receipts in a receipt box at the time office window within a certain number of days of the succeeding pay, which is not given out unless the previous one has been receipted. Occasionally the pay envelope, or a part of it, is made to answer for the receipt. Another plan is that used by the Cleveland Foundry Co. described under "Pay-off Methods."

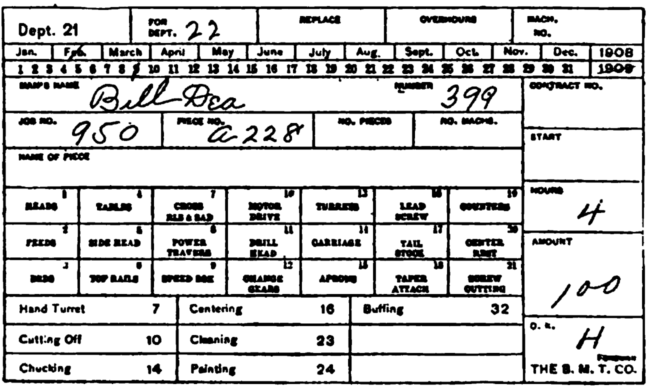
**359. Pay-off methods.** The general scheme in use several years ago was to line the men up after whistle time and march them past the pay window. To even things up, the high numbers would lead one week, and the low numbers next. The unfortunate man who happened to be in the middle, however, was forced to lose from 10 to 15 minutes each pay-day. The growing tendency toward the consideration of the employee has lead to different methods. One largely used is to have the paymaster or pay clerk circulate through the shop and hand the envelopes to the employees. An ingenious scheme is in use by the Cleveland Foundry Co., by which 1500 men are paid off in 10 minutes. The pay-roll is divided into seven stations, as nearly equal as they can be made, giving from 200 to 250 men per station. The receipt slip, which is printed with similar notation to the envelope is laid over it, with a sheet of carbon paper between, and both are filled out at the same time with the number, name and amount. The pay envelope goes to the paymaster to be filled, and the receipt slip to the foreman of the department, who has his men sign their slips in advance if the amounts are correct. On pay-day, the whistle blows 10 minutes earlier than usual, the men form in line at the designated stations and hand in the receipts as they receive their envelopes.

Where the pay is held back 1 week as is usually the case, to give the accounting and pay department time to have it in readiness, difficulties sometimes arise when employees quit without notice

and come back on the succeeding pay-day for their pay. The pay clerk may not know that the man has quit, or may think that he has been absent on account of sickness, and hand over the envelope. Thus it is possible for a man to avoid turning in his tool checks, and still get what pay he has coming. To avoid this, the practice is to hold back the pay of such absentees until the tool checks have been turned in and the tool slip returned to the time office signed by the tool foreman or crib tender; or until investigation of the case shows that the payment is justifiable.

**360. Checking the pay-roll for dummies.** While 9999 out of 10,000 employees in as responsible position as a pay clerk are undoubtedly honest, there is the ten thousandth to consider. For this purpose it is well to have the department foreman to keep book records of the names, numbers and rates of their employees, when they started and when quit. The progressive foreman will do this anyway for his own information, and it is a valuable check for the management to apply to the pay-roll occasionally. No attempt should be made to have the foreman check the individual hours of work, as he has enough on his hands as it is. Changes of rates and their date should be noted in the foreman's book, however.

**361. Mechanical distribution.** The Tabulating Machine Co., of Washington, D. C., furnished sorting machines and tabulating



Dept. 21 | FOR DEPT. 22 | REPLACE | OVERHOURS | MACH. NO.

Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | 1908

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | 1909

MAN'S NAME Bill Dea | NUMBER 399 | CONTRACT NO.

JOB NO. 950 | PIECE NO. A-228 | NO. PIECES | NO. MACHS. | START

NAME OF PIECE

HEADS 1 | TABLES 4 | CROSS RLS & SAD 7 | MOTOR DRIVE 10 | TURRETS 13 | LEAD SCREW 16 | COUNTERS 19 | HOURS 4

FEEDS 2 | SIDE HEAD 5 | POWER TRAVERSE 8 | DRILL HEAD 11 | CARRIAGE 14 | TAIL STOCK 17 | CENTER REST 20 | AMOUNT 100

BEDS 3 | TOP RAILS 6 | SPEED BOX 9 | CHANGE GEARS 12 | APRONS 15 | TAPER ATTACH 18 | SCREW CUTTING 21

Hand Turret 7 | Centering 16 | Buffing 32 | O. K. H

Cutting Off 10 | Cleaning 23

Chucking 14 | Painting 24 | FOREMAN THE B. M. T. CO.

FIG. 202.—A time card used at the Bullard plant.

machines to the Government which were used for tabulating the last census. Since that time, these machines have been adapted to factory and office accounting. They are used for preparing classified statistics of all kinds, the feature of the machines being the mechanical sorting of data according to any given topic.

Fig. 202 represents a time card from the Bullard Machine Tool Co.'s plant and Fig. 203 shows the same card "punched" ready for the sorting machine. This punching is done by hand by means of a gang punch, and takes but a moment. These cards register the

following data, month and year, day of month, department number, man number, job number, piece number and symbol, division number, contract number, number of hours, amount of direct labor, machine number. Also symbols which are punched to indicate replacement, non-productive and productive, regular hours, overtime, piecework allowance and piecework settlement.

*The sorting machine*, which is motor driven, contains a hopper into which the cards are placed. The machine is adjusted to sort according to a given subject, which may be any one of the items mentioned above; the motor is started and sorting proceeds at the

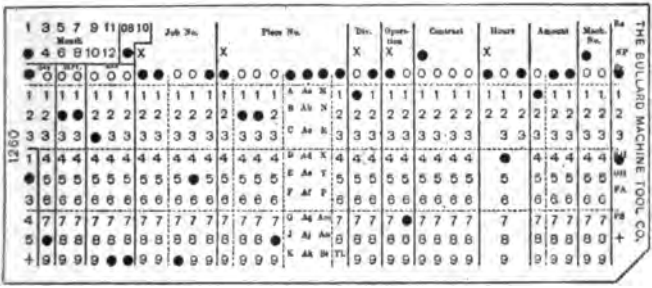



FIG. 203.—The Bullard time card perforated for tabulating.

rate of 240 cards per minute. The sorting process separates or selects cards according to one number or item at a time, for example, if it is desired to sort as to various departments, the machine would be set for the first number department, after this the cards remaining would be sorted for the second department number, and so on until the sorting is complete. In the Bullard plant, the cards are first sorted into "productive" and "non-productive." At the beginning of each week, all of the cards for the week preceding are ready to be sorted for the distribution. The first step is sorting to departments. The productive and non-productive items are then tabulated or totalled to determine the expenditure on each item in each department. Then the productive cards are sorted as to job numbers and the hours and amounts totalled under these numbers by departments as a means of obtaining costs of orders. The non-productive items are distributed once a month according to some 122 items. These monthly statements require 4 hours to prepare using this mechanical process.

**362. The advantages of mechanical tabulation** as defined by results obtained at the Pennsylvania Steel Co. are: *reduced expense* in connection with cost accounting; a *lessened time* necessary to prepare the monthly statement; and *distribution analysis* in great detail and of great elasticity and accuracy. The great advantage of the machine method is its freedom from error, for $10,000 can be divided into 200 items, and their sum will balance the original amount to a penny. Its largest field of application is where there are a great many cards to be handled, such as life insurance records

and telephone company's bills, but there is a field for it in the smaller plants. The fact that the machine performs its work so quickly and is therefore idle a large part of the time leads to the question as to why it would not pay several small plants to consider operating a machine of this type in common, and choosing different days for each one's work. One peculiar advantage of the type of card used is that it may be easily keyed so that the results would have absolutely no meaning to the ones handling the cards.

**363. Numbers Assigned to Operations.**

*List of Operation Numbers used in Santa Fe Railroad Shops*

1—Adjusted
2—Applied
3—Assembled
4—Babbitted
5—Bend
6—Blocked
7—Blow out
8—Bored
9—
10—Centered
11—Cleaned
12—Chipped
13—Closed
14—Connected up
15—Counterbored
16—Crated
17—Cut
18—
19—Delivered
20—Disconnected
21—Dismantled
22—Drilled
23—
24—Examined
25—Faced
26—Filed
27—Filled
28—Filleting
29—Fitted
30—Framed
31—
32—Gained
33—Glazed
34—Ground
35—
36—Inspected
37—Laid out
38—Lined
39—Lowered
40—
41—Made
42—Marked
43—Measured
44—Mortised
45—Moved
46—Oiled
47—Overhauled
48—Pulverized
49—Packed
50—Patched
51—Piened
52—Placed
53—Quartered
54—Raised
55—Reamed
56—Reduced
57—Removed
58—Replaced
59—
60—Renewed
61—Repaired
62—Riveted
63—Rounded
64—Retapped
65—Sawed
66—Scraped
67—Secured
68—Shimmed
69—Set
70—Spliced
71—Stenciled
72—Straightened
73—Stripped
74—
75—Tapped
76—Tested
77—Threaded
78—Tightened
79—Trammed
80—Trimmed
81—
82—Washed

## TIME STUDY

**364. What time study is for.** Time study has for its chief purpose the obtaining for the plant management of information as to the length of time that a job should take. This is quite different from time records showing how long the job has taken. It is really timekeeping placed on a scientific basis; science of any kind consisting of investigations which secure actual facts or truths.

Since the complete time study of an operation usually takes a great deal longer than the performance of the operation itself many times over, the question may arise, especially on work which

is not frequently repeated, as to its value in dollars and cents. This is best answered by the words of the chief exponent of time study methods, F. W. Taylor, as given in his book on "Shop Management."

"No system of time study can be looked upon as a success unless it enables the time observer, after a reasonable amount of study, to predict with accuracy how long it should take a good man to do almost any job in the particular trade. It is true that hardly any two jobs in a given trade are exactly alike, and that if a time student were to follow the old method of studying and recording the whole time required to do the various jobs which come under his observation, without dividing them into their elements, he would make comparatively small progress in a lifetime, and at best would become a skillful guesser. It is, however, equally true that all of the work done in a given trade can be divided into a comparatively small number of elements or units, and that with proper implements or methods, it is comparatively easy for a skilled observer to determine the time required by a good man to do any one of these elementary units.

"Having carefully recorded the time for each of these elements, it is a simple matter to divide each job into its elementary units, and by adding their times together, to arrive accurately at the total time for the job."

It is evident that the mere knowledge of the proper time for an operation will prove of little value unless it be connected definitely with activities as a standard of action. To this end, the results of time study are compiled in the form of *instruction cards* (see 394), detailing the proper manner in which to perform all of the elements of the operation, for use by the operator. In this way, *time study leads to standardized actions* and makes the best use of experience. To furnish an incentive to the operator other than the mandate of the management, the results of time study are combined into the compensation system used, so that one who performs the task in the proper time will be suitably rewarded. For this purpose the time observations constitute the basis of rate setting.

**365. The difference between timekeeping and time study observations.** Time study is really based on a special method of time taking, the ordinary shop time records not giving enough detail to be of value for the purpose of making time studies. For example, a lathe operator is given a cylinder to bore and face. The ordinary timekeeping methods would record this as follows:

(1) Boring and facing cylinder 2¾ hours.

In some plants where operation costs are kept, and the records are divided according to each operation performed, we might find the following:

| | | |
|---|---|---|
| (2) | boring cylinder | 1½ hours. |
| | facing cylinder | 1¼ hours. |

(Or, subdivided as to chuckings)

| | | |
|---|---|---|
| (3) | first-chucking | |
| | bore | 1½ hours. |
| | face | ½ hours. |
| | second chucking | |
| | face | ¾ hours. |

Carrying the subdivisions one step further, we might distinguish the chucking time from the cutting, and the rough from the finishing cuts.

| | |
|---|---|
| chuck | ½ hour. |
| rough bore | ¾ hour. |
| finish bore | ¼ hour. |
| rough face | ¼ hour. |
| finish face | ¼ hour. |
| rechuck | ¼ hour. |
| rough face | ¼ hour. |
| finish face | ¼ hour.[1] |

[1] Even quarter-hours would be an impossibility in an actual case.

When we reached this point of refinement, to have the various items timed with any degree of accuracy, we would have to put an "observer" at the machine, and not depend on the mechanic to keep the time records. And this may be said to be the line that divides time study from timekeeping.

Another distinguishing feature may be illustrated at this time. Take example (1) boring and facing cylinder, 2¾ hours. There is nothing interchangeable about the information conveyed; in other words, it could not be applied to anything except the particular piece on which the work was done. When we approach the detail which is entailed in time study, as in case 4, we begin to get interchangeable elements. For example, if our roughing time for boring a 5 × 5 inch hole is observed to be 45 minutes, and the machine has been operated properly, we would expect to get other holes of the same size in as good a time, even though the general shape of the casting was different, and the succeeding operations were different.

We have only begun to scratch the surface in the matter of subdivision. Each of the subdivisions in (4) may be further divided in great detail. The chucking in the above case is evidently a catch-all for the miscellaneous actions which occur before the cut, such as

Reading blueprint.
Putting sling around casting.
Lowering chain hoist and attaching sling.
Hoisting.
Getting clamps and bolts.
Preliminary securing to face-plate.
Taking off sling.
Trueing up.
Final tightening of clamps.

In similar manner, the time coming under the subdivision of rough boring in (4) could be elaborated into various actions, including:

Selecting tool.
Placing in tool post.
Adjusting tool.
Tightening tool.
Setting calipers, or securing gages.
Adjusting speed.
Adjusting feed.
Advancing or retracting cross slide.
Advancing carriage by hand.
Cutting for size.
Calipering.
Setting cross slide.
Throwing feed.
Rough cutting.
Disengaging feed.
Retracting carriage.

And so on for each of the subdivisions made in (4). By the time the analysis is completed we find that the simple operation (1) boring and facing cylinder, has become 100 or more separate actions. We would also find that the actual time of cutting was but a small portion of the whole, and probably the easiest of all to control since it may be done mechanically. The timing of these individual actions, and the study of the records so obtained constitutes "time study."

**366. Distinction between time study and motion study.** Going still a step further, we might pick out any one of the subdivided

actions above described and resolve it into elementary motions. Then, instead of 100 or more observations we would possibly have a thousand. This is "motion study."

It is obvious that to apply motion study, or even time study, as a substitute for our ordinary timekeeping methods would be a prohibitive expense, for we would need a time-study man for each operator. Time study, however, is not intended as a substitute for timekeeping, but as a means of securing accurate information regarding elementary and even complex operations so that we may know if they are being completed in the best manner and the shortest time.

**367. Interchangeable actions.** It is found with time or motion study, that the interchangeability of actions or motions reduces the necessary amount of work considerably. For example, the machine operator will go through the same motions in throwing his shifter to start and stop his machine, whether he is working on a large or small piece, and whether he is turning, boring or facing. So that this time, once obtained, stands good for any kind of work done upon that machine. It is quite similar to learning a new language—when we have mastered two or three hundred words it is possible to express any ordinary thought, whereas if we had to learn each possible sentence or construction it would be an endless task.

**368. Motion study methods.** The apparatus and methods of making motion studies is somewhat more complicated than that for time study. The human eye as a rule is not quick enough to separate and analyze each motion of an operator, much less time it. To overcome this difficulty, the moving picture machine has been used, making photographs of skilled operators engaged at certain operations. These are taken at the usual speed, but in using them are either run slowly, or studied individually, so that the eye has time to follow each motion. Such methods are out of the question unless the operations studied are repeated frequently enough and by enough employees to run into large amounts of money.

A simpler method has been used which consists of attaching an electric bulb to the operator's hand, and photographing the path of light on a sensitive plate, to show the path described by the hand, and determine if it has been the shortest one. The time element is sometimes measured in connection with the latter scheme by having the bulb flash at regular periods. Frank B. Gilbreth is the originator of this method.

In making use of motion studies to find the most efficient way to perform work, several skilled operators are chosen as subjects. The best ways of each are combined into a standard way as the result.

While so-called motion study is beyond the refinement of those in the average shop, motion study really is closely connected with time study, and follows it as a natural result. Without using moving picture apparatus, or cameras, the time study man when analyzing his records will give thought to arrangement of conveniences in connection with the length of time required on the analyzed actions. He may see that a shifter is wrongly placed, requiring the operator to stretch to reach it, or that the floor is a long w

from the chuck when it comes to lifting up castings, and that a casting bench should be provided. This is really motion study of a profitable kind.

**369. Distinction between handling time and machine time.** The ease of making time studies varies with the more or less automatic nature of the machine observed. Time study upon a wholly automatic machine would be a simple matter. It would be necessary only to secure a record of each operation, and one observation of each would be sufficient if accurately done, since the machine will repeat them similarly every time.

At the other extreme are observations made upon operations involving handwork alone. The human factor enters in with the elements of variable skill making it necessary to obtain repeated observations in order to strike an average. There is also the question of fatigue and consequent rest, which does not apply to the machine.

Many shop operations, and in fact the majority, consist of a combination of machine work with hand work. Whatever the machine does of itself without the physical help of the operator is machine work. On the ordinary machine such as the lathe, this is simply the actual cutting. On the gear cutter, it includes the indexing as well as the cutting. On the hand screw machine it includes in addition to the cutting, the feeding of the stock, the rotation of the turret and the throwing out of the feed at the end of the cuts.

Handling work done in connection with machine tools consists among other things of the actions necessary to place the work in the machine and secure it, the starting and stopping, the throwing in and out of the feed, the hand feeding where used, the measuring, the filing and polishing, the removal of the work after it is finished. It will be seen that the elements constituting handling time are much more complex than those constituting machine time. The greater part of the work of time study is connected with the handling time elements.

For convenience in using the results of time study for standard time and rate setting, as described in (385), it is necessary to make sharp division of handling time and machine time on the observation sheets.

**370. Time Study.** *Following is an excerpt from a discussion by F. W. Taylor* on the report on industrial management of a committee of the American Society of Mechanical Engineers. It sets forth both the *analytical and constructive work of time study* in the shop.

*The analytical work of time study* is as follows: (*a*) Divide the work of a man performing any job into simple elementary movements. (*b*) Pick out all useless movements and discard them. (*c*) Study, one after another, just how each of several skilled workmen makes each elementary movement, and with the aid of a stop-watch select the quickest and best method of making each elementary movement, known in the trade. (*d*) Describe, record and index each elementary movement, with its proper time, so [illegible] it can be quickly found. (*e*) Study and record the percentage

which must be added to the actual working time of a good workman to cover unavoidable delays, interruptions, and minor accidents, and so forth. (*f*) Study and record the percentage which must be added to cover the newness of a good workman to a job, the first few times that he does it. (This percentage is quite large on jobs made up of a large number of different elements composing a long sequence, infrequently repeated. This factor grows smaller, however, as the work consists of a smaller number of different elements in a sequence that is more frequently repeated.) (*g*) Study and record the percentage of time that must be allowed for rest, and the intervals at which the rest must be taken, to offset physical fatigue.

*The constructive work of time study* is as follows: (*a*) Add together into various groups such combinations of elementary movements as are frequently used in the same sequence in the trade, and record and index these groups so that they can be readily found. (*b*) From these several records, it is comparatively easy to select the proper series of motions which should be used by a workman in making any particular article, and by summing the times of these movements, and adding proper percentage allowances, to find the proper time for doing almost any class of work. (*c*) The analysis of a piece of work into its elements almost always reveals the fact that many of the conditions surrounding and accompanying the work are defective. For instance, that improper tools are used, that the machines used in connection with it need perfecting, that the sanitary conditions are bad, and the like, and knowledge so obtained leads frequently to constructive work of a high order, to the invention of superior methods and machines.

**371. Time-study methods.** The chief requisite for successful time study is an intelligent observer who is familiar with shop practice and has sufficient judgment to tell if a man is holding back or working up to his best capacity. His tools will be a stop watch and note book. Sometimes a portable desk is provided which may be wheeled to a favorable position near the work to be observed.

*Time observations* should be taken only after the method of doing the work has been studied in connection with the tool equipment used, so that it represents the best practice that can be devised. Otherwise it might be necessary to discard observations which cost considerable time, effort and money on account of a slight change in method. And it will generally be found that the results of the time study on any particular operation will result in discovering even better methods of handling the work, so that the best known at the time should be had at the start to get the very best after the work is done.

It is quite necessary to make exact notes of the means and process employed during the observation, the tool set up, the operator's name, and whether he is working up to capacity or holding back. Previous to making the time observations, the time sheet should be prepared in detail with the proper actions noted in their proper order, as the observer will seldom have time to do this work and manipulate the stop watch at the same time.

As a rule, observations should be made on first-class men,

although it is unfair in some cases to select the exceptionally skilled, as time limits might result in rate setting that would permit of no one but this man earning a premium.

Sometimes it is found desirable to make time studies in less detail than usually recommended, for example on work which occurs but seldom and which will not permit of the expense of elaborate time study work. Such work may be more broadly classified somewhat as follows:

Chucking.
Rough Cuts.
Finished Cuts.
Measuring.
Removing.

**372.** Geo. D. Babcock, production manager of the H. H. Franklin Co. of Syracuse, in describing the result of "Scientific Management,"

OBSERVER'S NAME Morss MACHINE NO. 59V.
WORKMAN'S NAME Turner 5617
Piece 19398—25 Differential Gear Section

| | Detailed Operations | 1 |
|---|---|---|
| 1 | Carry gears from pile to bench | |
| 2 | Pick up diff., land in vise and tighten | 0.15 |
| | | 0.43 |
| 3 | File corners off capscrews | 0.58 |
| | | 0.07 |
| 4 | Loosen vise, turn diff., tighten vise | 0.65 |
| | | 0.53 |
| 5 | File capscrews | 1.18 |
| | | 0.07 |
| 6 | Loosen vise, turn diff., tighten vise | 1.25 |
| | | 0.28 |
| 7 | File capscrews | 1.53 |
| | | 0.06 |
| 8 | Open vise | 1.59 |
| | | 0.11 |
| 9 | Turn diff, 90° tighten vise | 1.70 |
| | | 2.88 |
| 10 | Wipe grease off diff. burr edge of flange | 4.58 |
| | | 0.70 |
| 11 | Pick up gear, wipe off grease | 5.28 |
| | | 0.07 |
| 12 | Land gear on differential | 5.35 |
| | | 0.46 |
| 13 | Align holes in gear and diff. | 5.81 |
| | | 0.38 |
| 14 | Assem. 1st 5/16 in. capscrew and nut | 6.19 |
| | | 0.33 |
| 15 | Assem. 2nd 5/16 in. capscrew and nut | 6.52 |
| | | 1.09 |
| 16 | Tighten nuts with wrench | 7.61 |
| | | 0.16 |
| 17 | Loosen vise, turn piece end for end | 7.77 |
| | | 0.07 |
| 18 | Tighten vise | 7.84 |
| | | 1.46 |
| 19 | Align rivet holes with drift | 9.30 |
| | | 0.03 |
| 20 | Loosen vise | 9.33 |
| | | 0.10 |
| 21 | Land assem. in box | 9.43 |
| | | 0.13 |
| 22 | Return to bench | 9.56 |

Fig. 204.—Original time study

in the Franklin plant, gives some interesting examples of time study, with the resulting savings. American Machinist, vol. 40, p. 1063. In Fig. 204 are shown two time studies of assembling a bevel gear to the differential, study *A* being the preliminary one made before constructing the operator's instruction sheet, and study *B* representing the improved process selected as standard. Operation 1, study *A*, was eliminated in study *B* by having the material placed on the bench by the move man. Operations from 3 to 9*A* were combined into operation 2*B*. The man was instructed to do all burring with differential clamped in the vise after he had wiped off the grease. This eliminated loosening and tightening the vise three times. In a similar manner, by using thought the remaining operations are simplified and reduced until study *B* requires 3.77 minutes as against 8.69 minutes required under the original plan.

DATE 2-21-1914

| Study A 2 | 3 | 4 | 5 | 6 | 7 | 8 | Aver. | Min. Time |
|---|---|---|---|---|---|---|---|---|
| | | | | 0.09 | 8.41 | | | |
| | | | | 0.16 | 0.17 | | | |
| 0.16 | 0.17 | 0.12 | 0.16 | 0.25 | 8.58 | 0.16 | 0.156 | 0.13 |
| 0.57 | 0.78 | 0.58 | 0.62 | 0.62 | 0.65 | 0.71 | ...... | ...... |
| 0.73 | 0.95 | 0.70 | 0.78 | 0.87 | 9.23 | 0.87 | 0.620 | 0.50 |
| 0.11 | 0.04 | 0.27 | 0.07 | 0.10 | 0.11 | 0.11 | | |
| 0.84 | 0.99 | 0.97 | 0.85 | 0.97 | 9.34 | 0.98 | 0.0875 | 0.07 |
| 0.65 | 0.74 | 0.18 | 0.55 | 0.57 | 0.43 | 0.35 | | |
| 1.49 | 1.73 | 1.15 | 1.40 | 1.54 | 9.77 | 1.33 | 0.523 | 0.41 |
| 0.08 | 0.07 | 0.08 | 0.09 | 0.11 | 0.07 | 0.08 | | |
| 1.57 | 1.80 | 1.23 | 1.49 | 1.65 | 9.84 | 1.41 | 0.0813 | 0.07 |
| 0.28 | 0.41 | 0.35 | 0.51 | 0.60 | 0.21 | 0.44 | | |
| 1.85 | 2.21 | 1.58 | 2.00 | 2.25 | 10.05 | 1.85 | 0.385 | 0.30 |
| 0.08 | 0.08 | 0.10 | 0.09 | 0.12 | 0.07 | 0.08 | | |
| 1.93 | 2.29 | 1.68 | 2.09 | 2.37 | 10.12 | 1.93 | 0.085 | 0.07 |
| 0.09 | 0.07 | 0.08 | 0.14 | 0.11 | 0.05 | 0.11 | | |
| 2.02 | 2.36 | 1.76 | 2.23 | 2.48 | 10.17 | 2.04 | 0.095 | 0.08 |
| 2.43 | 1.76 | 1.44 | 1.29 | 1.56 | 1.76 | 1.53 | | |
| 4.45 | 4.12 | 3.20 | 3.52 | 4.04 | 11.93 | 3.57 | 2.60 | 0.22 |
| 0.48 | 0.49 | 2.08 | 1.48 | 1.64 | 1.39 | 2.02 | | |
| 4.93 | 4.61 | 5.28 | 5.00 | 5.78 | 13.32 | 5.59 | 0.524 | 0.43 |
| 0.12 | 0.13 | 0.14 | 0.23 | 0.10 | 0.10 | 0.08 | | |
| 5.05 | 4.74 | 5.42 | 5.23 | 5.88 | 13.42 | 5.67 | 0.105 | 0.08 |
| 0.71 | 1.31 | 0.45 | 0.43 | 0.20 | 0.55 | 0.37 | | |
| 5.76 | 6.05 | 5.87 | 5.66 | 6.08 | 13.97 | 6.04 | 0.558 | 0.45 |
| 0.13 | 0.25 | 0.23 | 0.22 | 0.17 | 0.22 | 0.77 | | |
| 5.89 | 6.30 | 6.10 | 5.88 | 6.25 | 14.19 | 6.81 | 0.264 | 0.22 |
| 0.23 | 0.23 | 0.20 | 0.22 | 0.31 | 0.33 | 0.54 | | |
| 6.12 | 6.53 | 6.30 | 6.10 | 6.56 | 14.52 | 7.35 | 0.296 | 0.22 |
| 0.63 | 1.05 | 0.88 | 0.98 | 1.02 | 0.60 | 0.82 | | |
| 6.75 | 7.58 | 7.18 | 7.08 | 7.58 | 15.21 | 8.17 | 0.895 | 0.72 |
| 0.11 | 0.02 | 0.08 | 0.10 | 0.08 | 0.12 | 0.10 | | |
| 6.86 | 7.60 | 7.26 | 7.18 | 7.66 | 15.33 | 8.27 | 0.0963 | 0.08 |
| 0.03 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | | |
| 6.89 | 7.64 | 7.29 | 7.21 | 7.69 | 15.36 | 8.30 | 0.0363 | 0.03 |
| 1.11 | 1.42 | 0.45 | 0.60 | 0.20 | 1.73 | 0.26 | | |
| 8.00 | 9.06 | 7.74 | 7.81 | 7.89 | 17.09 | 8.56 | 1.03 | 0.83 |
| 0.03 | 0.04 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | | |
| 8.03 | 9.10 | 7.97 | 7.84 | 7.91 | 17.12 | 8.59 | 0.30 | 0.03 |
| 0.12 | 0.20 | 0.12 | 0.12 | 0.11 | 0.12 | 0.11 | | |
| 8.15 | 9.30 | 7.89 | 7.96 | 8.02 | 17.24 | 8.70 | 0.125 | 0.10 |
| 0.17 | 0.10 | 0.11 | 0.11 | 0.18 | 0.09 | 0.12 | | |
| 8.32 | 9.40 | 8.00 | 8.07 | 8.20 | 17.33 | 8.82 | 0.126 | 0.10 |
| | | | Average total time | | | | 8.69 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OBSERVER'S NAME Hawksworth | MACHINE NO. 406 V. | | | | DATE 3-30-1914 | | | | | | | |
| WORKMAN'S NAME Trimian No. 334 | D3M | | | | 8.00 a.m. | | | | | | | |
| Piece 19398—32 Differential Gear Section | | | | | | | | | | | | |
| Study B | | | | | | | | | | | | |
| Detailed Operations | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Aver. | Min. Time |
| 1 Pick up diff., land in vise and tighten........ | 0.14 | 0.17 | 0.17 | 0.15 | 0.20 | 0.17 | 0.18 | 0.24 | 0.19 | 0.21 | 0.181 | 0.15 |
| 2 Wipe grease off diff. burr cap-screws and flange | 1.58 | 2.03 | 1.21 | 1.57 | 0.88 | 1.69 | 1.86 | 1.28 | 1.62 | 0.91 | | |
| | 1.72 | 2.20 | 1.38 | 1.72 | 1.08 | 1.86 | 2.04 | 1.52 | 1.81 | 1.12 | 1.27 | 1.05 |
| | 0.49 | 0.46 | 0.45 | 0.46 | 0.50 | 0.18 | 0.34 | 0.56 | 0.56 | 0.46 | | |
| 3 Land gear on differential.................... | 2.21 | 2.66 | 1.83 | 2.18 | 1.58 | 1.64 | 2.38 | 2.08 | 2.37 | 1.58 | 0.506 | 0.45 |
| | 0.19 | 0.34 | 0.27 | 0.28 | 0.18 | 0.16 | 0.18 | 0.19 | 0.19 | 0.18 | | |
| 4 Put 25/16-in. capscrews in gear and diff ...... | 2.40 | 3.00 | 2.10 | 2.46 | 1.76 | 1.80 | 2.56 | 2.27 | 2.56 | 1.76 | 2.16 | 0.17 |
| | 0.32 | 0.24 | 0.33 | 0.25 | 0.94 | 1.31 | 0.45 | 0.62 | 0.39 | 0.40 | | |
| 5 Start 2 nuts by hand...................... | 2.72 | 3.24 | 2.43 | 2.71 | 2.60 | 3.11 | 3.01 | 2.89 | 2.95 | 2.76 | 0.415 | 0.33 |
| | 0.33 | 0.27 | 0.44 | 0.29 | 0.33 | 0.22 | 0.25 | 0.40 | 0.31 | 0.11 | | |
| 6 Tighten nuts with wrench.................. | 3.05 | 3.51 | 2.87 | 3.00 | 2.93 | 3.33 | 3.26 | 3.29 | 3.26 | 2.27 | 0.305 | 0.25 |
| | 0.15 | 0.12 | 0.10 | 0.10 | 0.11 | 0.09 | 0.09 | 0.07 | 0.08 | 0.09 | | |
| 7 Loosen vise, lay assem. on bench............ | 3.20 | 3.63 | 2.97 | 3.10 | 3.03 | 3.42 | 3.35 | 3.36 | 3.34 | 2.36 | 0.099 | 0.08 |
| | 0.18 | 0.90 | 0.55 | 0.30 | 0.67 | 0.25 | 0.27 | 0.54 | 0.49 | 0.66 | | |
| 8 Test holes for align. using rivet............ | 3.38 | 4.53 | 3.52 | 3.40 | 3.70 | 3.67 | 3.62 | 3.90 | 3.83 | 3.02 | 0.471 | 0.40 |
| | 0.10 | 0.13 | 0.10 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.14 | 0.15 | | |
| 9 Lay assem. on box...................... | 3.48 | 4.66 | 3.62 | 3.51 | 3.81 | 3.78 | 3.72 | 4.00 | 3.97 | 3.17 | 0.115 | 0.09 |
| | | | | | | Average total time | | | | | 3.77 | |

O.K. by J. E. B.

FIG. 204.—Improved records obtained through time study.

## Observation Sheet

| | | | |
|---|---|---|---|
| Observer's Name | Hawksworth | Machine No. 7 D.S. | Date 1-14-1914 |
| Workman's Name | Burns | No. 250. | |
| And Qualifications | | | |
| Piece 18666 | Steering Device Tube and Case Drill for Grease Cup | | |

| Study 1 Detailed Operations | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Aver. | Min. Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A Pick up tube and case, land on V-block | 0.15 | 0.18 | 0.18 | 0.19 | 0.20 | 0.19 | 0.20 | 0.14 | 0.12 | 0.12 | 0.12 | 0.163 | 0.13 |
| | 0.13 | 0.22 | 0.15 | 0.16 | 0.19 | 0.16 | 0.29 | 0.12 | 0.16 | 0.14 | 0.18 | | |
| B Align tube, locate drill | 0.28 | 0.40 | 0.33 | 0.35 | 0.39 | 0.35 | 0.49 | 0.26 | 0.28 | 0.26 | 0.30 | 0.173 | 0.14 |
| C Drill 11/32 inch, 580 r.p.m., hand feed | 0.30 | 0.35 | 0.24 | 0.37 | 0.34 | 0.39 | 0.29 | 0.22 | 0.28 | 0.22 | 0.23 | | |
| | 0.58 | 0.75 | 0.57 | 0.72 | 0.73 | 0.74 | 0.78 | 0.48 | 0.56 | 0.48 | 0.53 | 0.294 | 0.22 |
| | 0.06 | 0.10 | 0.12 | 0.08 | 0.15 | 0.16 | 0.22 | 0.16 | 0.09 | 0.11 | 0.07 | | |
| D Land tube in box | 0.64 | 0.85 | 0.69 | 0.80 | 0.88 | 0.90 | 1.00 | 0.64 | 0.65 | 0.59 | 0.60 | 0.120 | 0.10 |
| | | | | | | | | | | | Total aver = | 0.749 | 0.59 |
| **Study 2** | | | | | | | | | | | | | |
| E Pick up tube and case, land on V-block | 0.10 | 0.10 | 0.10 | 0.10 | 0.09 | 0.12 | 0.10 | 0.10 | 0.11 | | | 0.103 | 0.09 |
| | 0.09 | 0.10 | 0.12 | 0.08 | 0.07 | 0.08 | 0.08 | 0.08 | 0.09 | | | | |
| F Align tube, locate drill | 0.19 | 0.20 | 0.22 | 0.18 | 0.16 | 0.20 | 0.18 | 0.18 | 0.20 | | | 0.0878 | 0.07 |
| | 0.14 | 0.12 | 0.16 | 0.17 | 0.14 | 0.14 | 0.11 | 0.13 | 0.15 | | | | |
| G Drill 11/32 inch, 580 r.p.m., hand feed | 0.33 | 0.32 | 0.38 | 0.35 | 0.30 | 0.34 | 0.29 | 0.31 | 0.35 | | | 0.140 | 0.11 |
| | 0.05 | 0.08 | 0.06 | 0.07 | 0.07 | 0.05 | 0.06 | 0.06 | 0.05 | | | | |
| H Land tube in box | 0.38 | 0.40 | 0.44 | 0.42 | 0.37 | 0.39 | 0.35 | 0.37 | 0.40 | | | 0.0611 | 0.06 |
| | | | | | | | | | | | Total aver. = | 0.391 | 0.33 |

FIG. 205.—Time study of drilling a hole for a grease cup.

OBSERVER'S NAME Hawksworth MACHINE NO. 406 V. DATE 3-30-1914
WORKMAN'S NAME Trimian No. 334 D3M 8.00 a.m.
Piece 19398—32 Differential Gear Section
Study B

| Detailed Operations | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Aver. | Min. Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Pick up diff., land in vise and tighten........ | 0.14 | 0.17 | 0.17 | 0.15 | 0.20 | 0.17 | 0.18 | 0.24 | 0.19 | 0.21 | 0.181 | 0.15 |
| 2 Wipe grease off diff. burr cap-screws and flange | 1.58 | 2.03 | 1.21 | 1.57 | 0.88 | 1.69 | 1.86 | 1.28 | 1.62 | 0.91 | | |
| | 1.72 | 2.20 | 1.38 | 1.72 | 1.08 | 1.86 | 2.04 | 1.52 | 1.81 | 1.12 | 1.27 | 1.05 |
| | 0.49 | 0.46 | 0.45 | 0.46 | 0.50 | 0.18 | 0.34 | 0.56 | 0.56 | 0.46 | | |
| 3 Land gear on differential.................. | 2.21 | 2.66 | 1.83 | 2.18 | 1.58 | 1.64 | 2.38 | 2.08 | 2.37 | 1.58 | 0.506 | 0.45 |
| | 0.19 | 0.34 | 0.27 | 0.28 | 0.18 | 0.16 | 0.18 | 0.19 | 0.19 | 0.18 | | |
| 4 Put 2 5/16-in. capscrews in gear and diff ...... | 2.40 | 3.00 | 2.10 | 2.46 | 1.76 | 1.80 | 2.56 | 2.27 | 2.56 | 1.76 | 2.16 | 0.17 |
| | 0.32 | 0.24 | 0.33 | 0.25 | 0.94 | 1.31 | 0.45 | 0.62 | 0.39 | 0.40 | | |
| 5 Start 2 nuts by hand...................... | 2.72 | 3.24 | 2.43 | 2.71 | 2.60 | 3.11 | 3.01 | 2.89 | 2.95 | 2.76 | 0.415 | 0.33 |
| | 0.33 | 0.27 | 0.44 | 0.29 | 0.33 | 0.22 | 0.25 | 0.40 | 0.31 | 0.11 | | |
| 6 Tighten nuts with wrench................. | 3.05 | 3.51 | 2.87 | 3.00 | 2.93 | 3.33 | 3.26 | 3.29 | 3.26 | 2.27 | 0.305 | 0.25 |
| | 0.15 | 0.12 | 0.10 | 0.10 | 0.11 | 0.09 | 0.09 | 0.07 | 0.08 | 0.09 | | |
| 7 Loosen vise, lay assem. on bench........... | 3.20 | 3.63 | 2.97 | 3.10 | 3.03 | 3.42 | 3.35 | 3.36 | 3.34 | 2.36 | 0.099 | 0.08 |
| | 0.18 | 0.90 | 0.55 | 0.30 | 0.67 | 0.25 | 0.27 | 0.54 | 0.49 | 0.66 | | |
| 8 Test holes for align. using rivet............ | 3.38 | 4.53 | 3.52 | 3.40 | 3.70 | 3.67 | 3.62 | 3.90 | 3.83 | 3.02 | 0.471 | 0.40 |
| | 0.10 | 0.13 | 0.10 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.14 | 0.15 | | |
| 9 Lay assem. on box........................ | 3.48 | 4.66 | 3.62 | 3.51 | 3.81 | 3.78 | 3.72 | 4.00 | 3.97 | 3.17 | 0.115 | 0.09 |

Average total time 3.77

O.K. by J. E. B.

FIG. 204.—Improved records obtained through time study.

## Observation Sheet

| | | | |
|---|---|---|---|
| Observer's Name | Hawksworth | Machine No. 7 D.S. | Date 1-14-1914 |
| Workman's Name And Qualifications | Burns | No. 250. | |
| Piece 18666 | Steering Device Tube and Case Drill for Grease Cup | | |

| Study 1 Detailed Operations | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Aver. | Min. Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A Pick up tube and case, land on V-block | 0.15 | 0.18 | 0.18 | 0.19 | 0.20 | 0.19 | 0.20 | 0.14 | 0.12 | 0.12 | 0.12 | 0.163 | 0.13 |
| | 0.13 | 0.22 | 0.15 | 0.16 | 0.19 | 0.16 | 0.29 | 0.12 | 0.16 | 0.14 | 0.18 | | |
| B Align tube, locate drill | 0.28 | 0.40 | 0.33 | 0.35 | 0.39 | 0.35 | 0.49 | 0.26 | 0.28 | 0.26 | 0.30 | 0.173 | 0.14 |
| C Drill 11/32 inch, 580 r.p.m., hand feed | 0.30 | 0.35 | 0.24 | 0.37 | 0.34 | 0.39 | 0.29 | 0.22 | 0.28 | 0.22 | 0.23 | | |
| | 0.58 | 0.75 | 0.57 | 0.72 | 0.73 | 0.74 | 0.78 | 0.48 | 0.56 | 0.48 | 0.53 | 0.294 | 0.22 |
| | 0.06 | 0.10 | 0.12 | 0.08 | 0.15 | 0.16 | 0.22 | 0.16 | 0.09 | 0.11 | 0.07 | | |
| D Land tube in box | 0.64 | 0.85 | 0.69 | 0.80 | 0.88 | 0.90 | 1.00 | 0.64 | 0.65 | 0.59 | 0.60 | 0.120 | 0.10 |
| | | | | | | | | | | | Total aver = | 0.749 | 0.59 |

| Study 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Aver. | Min. Time |
|---|---|---|---|---|---|---|---|---|---|---|---|
| E Pick up tube and case, land on V-block | 0.10 | 0.10 | 0.10 | 0.10 | 0.09 | 0.12 | 0.10 | 0.10 | 0.11 | 0.103 | 0.09 |
| | 0.09 | 0.10 | 0.12 | 0.08 | 0.07 | 0.08 | 0.08 | 0.08 | 0.09 | | |
| F Align tube, locate drill | 0.19 | 0.20 | 0.22 | 0.18 | 0.16 | 0.20 | 0.18 | 0.18 | 0.20 | 0.0878 | 0.07 |
| | 0.14 | 0.12 | 0.16 | 0.17 | 0.14 | 0.14 | 0.11 | 0.13 | 0.15 | | |
| G Drill 11/32 inch, 580 r.p.m., hand feed | 0.33 | 0.32 | 0.38 | 0.35 | 0.30 | 0.34 | 0.29 | 0.31 | 0.35 | 0.140 | 0.11 |
| | 0.05 | 0.08 | 0.06 | 0.07 | 0.07 | 0.05 | 0.06 | 0.06 | 0.05 | | |
| H Land tube in box | 0.38 | 0.40 | 0.44 | 0.42 | 0.37 | 0.39 | 0.35 | 0.37 | 0.40 | 0.0611 | 0.06 |
| | | | | | | | | | Total aver. = | 0.391 | 0.33 |

FIG. 205.—Time study of drilling a hole for a grease cup.

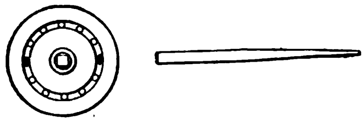


FIG. 204.—(See Table p. 270.)

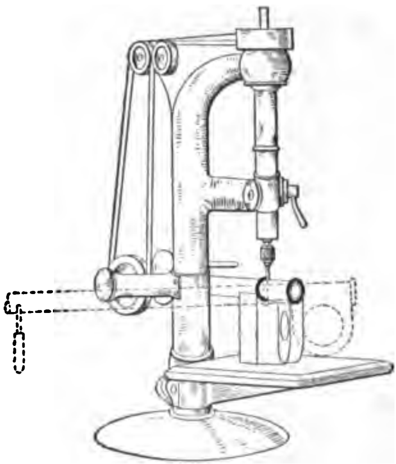


FIG. 205.—(See Table p. 271.)
Modification of set-up used in Fig. 204.

Fig. 205 illustrates the savings in cost which result from careful time study. These examples taken from actual successful practice are a strong argument for the value of time-study.

**373.** Fig. 206 is a set of time observations made at the Link Belt Co's plant. This requires no explanation and shows how one set of observations may be made to cover a great range of sizes.

**Observer's Name, L. Klauke** **Machine, Brown & Sharpe Gear Cutters, Builders' No. 3, 4, 5, 6.**

**Workman's Name. Walter Norgrave Date, 6-29-05. Piece, Shop No. 111. 112, 113, 117, 118, 119, 123; 4c., 7c., 8c., 5c., 6c., 2c., 3c.,**

**Weight, up to 2000 lb.; time in hours.**

| Handling time found on ins. card | Preparation | Time for high rate |
|---|---|---|
| 4470 | Extra time for setting and removing first wheel........................ | 0.110 |
| 4472 | Changing arbors (not allowed on 6c., and 7c. .......................... | 0.075 |
| 4475 | Setting cutters, all kinds............ | 0.065 |
| 4479 | Setting roughed out wheels to cutters | 0.019 |

| Operations | Handled by hand up to 100 lb. | Handled by hoist Yale & Towne 4000 lb. triplex: Above 100 lb. up to 500 lb. | Above 500 lb. up to 1000 lb. | Above 1000 lb. up to 2000 lb. |
|---|---|---|---|---|
| 1 Roll or carry wheel to machine, 10 ft. away........................ | 0.00250 | 0.00250 | 0.00350 | 0.00350 |
| 2 Put mandrel bushing in wheel..... | 0.00250 | 0.00250 | 0.00333 | 0.00333 |
| 3 Put chain on wheel (around rim) and on hoist hook............... | ....... | 0.00133 | 0.00133 | 0.00133 |
| 4 Chain draw taut (by hoist)......... | ....... | 0.00100 | 0.00100 | 0.00100 |
| 5 Hoist wheel (*L*–216)............. | ....... | ....... | ....... | ....... |
| 6 Trolley wheel to position............ | ....... | 0.00167 | 0.00167 | 0.00167 |
| 7 Put wheel on arbor ............... | 0.00167 | 0.00383 | 0.00383 | 0.00383 |
| 8 Remove chain from hook and from rim of wheel.................... | ....... | 0.00083 | 0.00083 | 0.00083 |
| 9 Trolley hoist away.................. | ....... | 0.00067 | 0.00067 | 0.00067 |
| 10 Bridge hoist away.................. | ....... | 0.00183 | 0.00183 | 0.00183 |
| 11 Put nut on arbor.................. | 0.00200 | 0.00200 | 0.00200 | 0.00200 |
| 12 Tighten nut, up to 1-½"-*t* = 0.002, above 1-½"-*t* = 0.00167 + 0.0025*B* | ....... | ....... | ....... | ....... |
| 13 Run up back nut............... | 0.00083 | 0.00083 | 0.00083 | 0.00083 |
| 14 Adjust screw in rim rest.......... | 0.00133 | 0.00133 | 0.00133 | 0.00133 |
| 15 Start machine, feed in............ | 0.00083 | 0.00083 | 0.00083 | 0.00083 |
| 16 Run cutters.................... | 0.00133 | 0.00133 | 0.00133 | 0.00133 |
| 17 Stop machine.................. | 0.00033 | 0.00033 | 0.00033 | 0.00033 |
| 18 Feed out catch back...........<br>19 Run cutters back............. | 0.00150 | 0.00150 | 0.00150 | 0.00150 |
| 20 Loosen arbor nut............... | 0.00167 | 0.00167 | 0.00217 | 0.00217 |
| 21 Remove arbor nut with wrench.... | 0.00117 | 0.00117 | 0.00117 | 0.00117 |
| 22 Run screw back in rim rest........ | 0.00117 | 0.00117 | 0.00117 | 0.00117 |
| 23 Force wheel loose *F* = 0.00167 × *B* (diameter of bore in inches)...... | ....... | ....... | ....... | ....... |
| 24 Bridge hoist to machine........... | ....... | 0.00183 | 0.00183 | 0.00183 |
| 25 Trolley hoist to machine.......... | ....... | 0.00067 | 0.00067 | 0.00067 |
| 26 Put chain around rim and on hoist hook............................ | ....... | 0.00133 | 0.00133 | 0.00133 |
| 27 Chain drawn taut by hoist........ | ....... | 0.00100 | 0.00100 | 0.00100 |
| 28 Remove wheel from arbor......... | 0.00133 | 0.00250 | 0.00250 | 0.00250 |
| 29 Trolley wheel to one side, 5 ft. .... | ....... | 0.00067 | 0.00067 | 0.00067 |
| 30 Lower wheel to floor (*L*–216)....... | ....... | 0.00383 | 0.00383 | 0.00383 |
| 31 Remove chain from hook and wheel | ....... | 0.00083 | 0.00083 | 0.00083 |
| 32 Remove bushing from wheel....... | 0.00083 | 0.00083 | 0.00083 | 0.00083 |
| 33 Put tag on wheel................ | 0.00167 | 0.00167 | 0.00167 | 0.00167 |
| 34 Roll or carry wheel to one side (10 ft.) | 0.00250 | 0.00250 | 0.00350 | 0.00350 |
| Total minimum time, operation 5, 12, 23 and 30 not included....... | 0.02516 | 0.04598 | 0.04531 | 0.04931 |

FIG. 206.—Tabulation of handling time observations of hand work on machine tool time for putting wheels in gear cutters and removing.

| Formula for machine time. (face" + clearance") × teeth | | Bore of wheel in in. | | | | |
|---|---|---|---|---|---|---|
| Cutter r.p.m. × feed per rev. = time in minutes. | Handling time to allow | 2 | 0.0476 | 0.0875 | 0.100 | 0.112 |
| | | 3 | 0.0540 | 0.0937 | 0.107 | 0.118 |
| | | 4 | 0.0603 | 0.100 | 0.113 | 0.124 |
| | | 5 | 0.0666 | 0.106 | 0.120 | 0.131 |
| | | 6 | 0.0726 | 0.113 | 0.126 | 0.137 |
| | | 7 | 0.0790 | 0.119 | 0.132 | 0.143 |
| | | 8 | 0.0852 | 0.125 | 0.138 | 0.149 |
| | | 9 | 0.0915 | 0.131 | 0.144 | 0.156 |
| | | 10 | 0.0977 | 0.138 | 0.150 | 0.162 |
| | | 11 | 0.104 | 0.144 | 0.157 | 0.167 |
| | | 12 | 0.110 | 0.150 | 0.163 | 0.174 |

Minimum handling time + 50 per cent. = Time allowed.

Formula and constants for machine time.

**374.** The principles of time study are applicable to all of the trades in which manual and mechanical labor are combined. One of the departments which can profit greatly by time study and yet to which it is seldom applied, is the foundry. The following is an illustration of time study of a molding-machine operation, reproduced from the American Machinist, vol. 39, p. 616.

Description of operation. Molding Drag and Cope. Hardware castings malleable. Barred flask 21½ by 14½ in., 2¾ in. drag, 2¾ in. cope *F*-4. High-speed molding machine.

| Operator | Seconds | Fractions of minutes | Fractions of minutes | Seconds | Helper |
|---|---|---|---|---|---|
| Pick up drag and put it in place.............. | 1.9 | 0.032 | 0.174 | 10.4 | Blow off pattern plate, swing sand frame above cope, shake parting and riddle sand on pattern. |
| Fill up drag (2 shovelfuls and put sand in riddle | 6.4 | 0.107 | 0.115 | 6.9 | Fill up cope (2 shovelfuls). |
| Riddle sand on drag top. | 9.0 | 0.150 | ..... | .... | .................... |
| Strike off surplus sand.... | 4.5 | 0.075 | 0.075 | 4.5 | Strike off surplus sand. |
| Swing on the pressing head and lock it....... | 1.8 | 0.030 | 0.123 | 7.4 | Swing on pattern plate with cope on |
| Squeeze and hook cope.. | 5.5 | 0.090 | ..... | .... | .................... |
| Draw pattern plate and finish gate holes with fingers............... | 7.7 | 0.130 | 0.056 | 5.6 | Start vibrator. |
| Apply pressure to close mold and unhook cope. | 1.9 | 0.031 | 0.065 | 3.9 | Swing out pattern plate and put cope on. |
| Release pressure—spring out pressing head and lock finished mold..... | 1.8 | 0.030 | 0.030 | 1.8 | Lock finished mold. |
| Place mold on floor (on end)................ | 4.5 | 0.075 | 0.075 | 4.5 | Place mold on floor (on end). |
| Total.............. | 45.0 | 0.750 | 0.750 | 45.0 | |

No. 7 riddle. No. 7 riddle.

| | Lb. |
|---|---|
| Weight of an empty shovel.................................... | 6 |
| Weight of sand in shovel..................................... | 22 |
| Number of shovels in each partof flask....................... | 2–44 |
| Weight of sand in the two parts of flask..................... | 88 |
| Weight of the two empty parts of flask....................... | 82½ |
| Total weight................................................ | 170½ |

FIG. 207.—Time study of molding operation.

**375. Time studies in the small shop.** It has been stated that time-study methods may not pay under certain conditions, such as too great a variety of work which is not repeated frequently. The small manufacturing plant which works on a fixed line of work offers great opportunities for economies effected through time study. Not only will better methods present themselves through its use, but it is the only proper way to proceed toward setting piece rates or premium time limits. In many cases it will pay to have a special time-study man where the number of operators does not number over a dozen. Assuming that the average day rate of such a shop is $2.50 per man, and that the profit per man averages 50 cents per day, it would be a paying investment to have a man for this purpose and pay him $3 per day, since the output per man will generally be doubled by time study and the resulting premium rates. For, assuming that the firm gains nothing in immediate profits after paying for the time studies, it is not long before the small line is thoroughly standardized. Also, when the small shop grows, and a small shop which is progressive enough to adopt such methods is sure to, the additional profits coming through the employment of more hands will well repay the initial cost of standardized time. In many cases, the foreman or timekeeper in a small plant can find the time to make one or two time studies a week, which if continued faithfully will cover the field in a comparatively short time. The head of a small shop is frequently a practical mechanic himself, and since as a rule he does not hesitate to put in more than the usual number of hours per day to advance his business, no better way can be found to do so than to take the records of time study home with him and devise short cuts and improved methods.

**376. Physical conveniences in assembly.** Time study of assembly operations will indicate the possibility of cost reductions through installing special conveniences for handling the work. In large typewriter plants, for example, not only is the assembly divided into distinct operations which are performed by specialists, but great attention is given to the construction of the benches, tables, work holders, and the like, which are used by the men, so that all material is available in most convenient form with the least expenditure of energy required to reach it. Hand motions are of their nature likely to be so much less efficient than the machine operations that this is an especially fertile field for improvements.

**377. The use of physical conveniences** is not restricted to the assembly department altogether. As an illustration of this, the author observed in a large clock factory a group of automatic screw machines which were arranged on a bench in single lines covering possibly 100 or 150 feet in length. To facilitate the movements of the operator who attended to these machines, he was provided with a stool mounted on wheels running upon a track which extended the entire length of the bench. A slight push or pull upon the bench moved the operator upon his movable stool to any machine which required attention in much less time and with much less expenditure of energy than would be required if the operator had walked. In this way one man was able to look after 25 or 30 machines without undue exertion.

## RATE SETTING

**378. Selection of a working principle with regard to rate setting.** The first step in rate setting is the selection of a working principle, or standpoint with regard to the extent that the worker is to benefit with the firm in connection with the savings made. This will vary according to whether a fair profit is or is not already being made. The more liberal the policy pursued, the better will be the general results obtained.

*Before making rates*, all changes found desirable or necessary through the time study should be made. The operator's confidence should be secured by taking him into consultation in the matter and listening attentively to any suggestions or complaints that he may have to make.

**379.** J. C. Spence, superintendent of the Norton Grinding Co., in a paper presented at the Machine-tool Builders Convention, 1914, has this to say with regard to *a new principle in rate setting:*

> The rates are set on the principle that since it has been found possible to reduce the cost and the concern was satisfied with that cost before this discovery, then the new rate can be placed well above what it can be actually done for. This is contrary to the old spirit of management, but is right in line with what most machine-tool men, at least, believe, and is the only way you can get your men into business for themselves.

Speaking of the proper qualifications of a rate setter, Mr. Spence says:

> I believe the greater savings can be made by having a skilled man study the job from an inventor's standpoint, rather than from that of an historian or recorder; all interferences with production are not evident to a mere observer. A management that will accept, without considering it as a personal affront, the statement that it is not as efficient as it could easily be made, and is so constituted mentally that it is eager to share with the producer in any saving that may be made, will easily find ways to reduce cost, and need have no fear of either being unable to get good men or to hold them loyal.

**380. Effect of rates based on time study upon the workmen.** Geo. D. Babcock, production manager of the H. H. Franklin Co. of Syracuse, in a paper presented before the National Metal Trades Association, has this to say regarding the process of making time studies and the effects on the employees of prices which are based upon them:

> Time studies have been made almost entirely on the shop floors. These could be made in a time-study laboratory with selected men, but we lose one of the most vital things for satisfactory conduct of this work, and that is what may be called the "shop constant" and fatigue allowance. We must make our time studies under the conditions we expect to operate. If made in a laboratory we must expect to operate under the highest possible efficiency as indicated by the laboratory method after the work is put into the shop. Few shops have operating standards sufficiently high to do this. It takes time and a great amount of work and cost to reach high standards, but it is without doubt the desirable end to obtain.
>
> On the alternate day after the workman's effort he is given a report of his accomplishment of the day. This report shows the parts worked on, the daywork earnings, and the premium earnings. Our method of pay is a fixed day rate with premium, not because we have selected this as being the best, but for the reason that almost any method of pay if based on time study will be fairly satisfactory.
>
> A recent study of the record of men working under time study shows a high percentage of attendance and a considerable reduction in lates as compared to periods before they were working under time study. There was no indication by absences or lates of fatigue of the workman. It is remarkable to note, as mentioned, that the attendance has been materially better, and especially noticeable because the base or day-rate was not re-

duced but has been gradually increased; the men's earnings are higher than before, and it is evident that they are not obliged to attend work on account of lack of sufficient pay as compared to the previous period. I am absolutely satisfied that there is not only no increase of fatigue for a given effort, but that there is a general decrease due to the continued uniformity of effort, and the better preparation and maintenance of tools and equipment.

**381. Basis of rates.** The basis for rates depends upon the degree of refinement of the methods and time systems obtaining in the plant. The following are four different plans from which rates are based: Arbitrarily; on past performance; on demonstration; on time study.

**382. Arbitrary rating.** Arbitrary rate setting is not as frequent as it was formerly. In making rates in this manner, the foreman, who was usually the rate setter, would "use his judgment" regarding the price. The result was an interesting series of prices ranging in correctness from those in which a good man would have to hustle to make a half day's pay in 10 hours, to those which were regarded as soft. Occasionally one would be nearly right, but it was more luck than science. The author had experience in a foundry where this method of rate setting existed, and found that the foreman had his hands full keeping his men pacified and dividing up the good jobs. The only apparent advantage was the ease of getting rid of an undesirable without firing him, which could be done by running him on "cheap" jobs for a few days.

**383. Past performance as a basis.** Basing the prices or rates on past performance was somewhat better. That is, when records of past performance had been kept which allowed the separation of time on operations that were to be priced. A common plan is to assume that the day-worker does not exert himself to his full extent, which is probably true, and allow a percentage to cover this. This percentage varies from 30 to 40 per cent. For example, in setting a piece price based on a past performance which cost 30 cents for the operation, from 9 to 12 cents would be deducted for the piece price. Similarly, in setting time limits for premium plans, the base time would be calculated by dividing the performance record by from 60 to 70 per cent.

*The disadvantage* of basing prices on past performance records lies in the fact that old methods are taken as standard, instead of looking for something better. A change in the method of compensation is an opportune time to change the method of doing the work, if there is a better one to be had. There is also the disadvantage with this scheme that it does not necessarily embody the proper time with the method considered, even with the allowances for holding back which are usually deducted. For example, in one case the record may be based on the work of an exceptionally skillful and industrious workman who could not better his performance materially under piecework; in another case it may be based on the time of a professional "soldier."

**384. Demonstration as a basis.** A skillful operator is called upon to finish the piece or perform the operation in question, and prices are based on the results so obtained plus usually a small allowance. If we could select a demonstrator who would be a typical average man as far as skill is concerned on all kinds of work, this scheme would not be bad. The difficulty comes in getting such a demonstrator. He is likely to be an expert on one

machine or line of work, and below the average on others. Prices will be closer when set on demonstrated time, but they will not be right nor fair. It is not always a correct argument that "if I can do this you can," as evidenced in the cases of the circus performer and his spectators. Some demonstrators are really "circus performers" on some particular jobs, and the attainment of their performance is as difficult to the average man as to accomplish such a feat as walking the tight rope. Demonstrators have their value, as teachers (see 398), but as rate setters they are not entirely satisfactory.

**385. Time study as a basis.** The proper plan is unquestionably that of basing the rates on the results of time study. This eliminates the disadvantage of unreasonable standards, which is found with the other methods, and also gives the clearest possible indication of improved methods which may be embodied. The matter of the degree of skill represented or called for by the rate must be determined by the general policy in the matter of rate setting, as described in (378–379).

**386. Minimum time.** Minimum or least time, as it is sometimes called, is the time derived from combining the time-study elements representing standard performance for each of the elements composing the operation, and eliminating all unnecessary ones. The periods of rest do not enter minimum time, or allowances of any other nature.

**387. Base, or allowed time,** is the time given to the workman, or used as a basis for the piece price. It is composed of the minimum time plus a figure representing allowances for fatigue, and other necessary factors.

**388. Allowance for fatigue.** This is a factor which varies from 20 to 80 per cent. according to the nature of the work and the amount of strain involved. Heavy work will call for the larger allowance, and light work which is done without much strain may take the smaller one. The selection of fatigue allowances is a matter which can be determined only by experience and which requires considerable judgment. The allowance for fatigue is figured solely on handling time.

**389. Allowance on machine time.** Although a machine does not feel the effects of fatigue, it is customary to allow a factor over and above the actual machine time as determined by time study. This varies from 7½ per cent. to 15 per cent. according to the nature of the machine and the work.

**390. Additional allowances.** Additional allowances are added in some plants; for example, in one plant it is customary to allow 15 minutes per day flat time for the personal needs of the operator, and 30 minutes for the care of the tools. Whether these factors are cared for by separate allowances, or are included in the two general allowances first mentioned is an optional matter. In the plant where this practice is followed, the base time is arrived at in the following manner: To all of the time-study time is added all of the setting up time, plus the percentage of the 15 minutes per day for personal use of the operator, and the 30 minutes per day for tool care which is chargeable to the job. The result obtained is increased by a flat 35 per cent. to establish the base time.

**391. Examples of different methods of computing base time.**

(a) From results of time study on heavy engine assembly, the minimum time is found to be 30 hours. As this work is physically hard and requires considerable lifting, we add to the base a fatigue allowance of 70 per cent., arriving at a base time of 51 hours. Previous best record was 65 hours.

(b) Boring and facing small gears in turret lathe.

| *Time-Study Results* | *Allowances, per cent.* |
|---|---|
| Handling, per 100, 6 hours. | 40 on handling, 2.4 hours. |
| Machine time, 100, 2 hours. | 10 on mach. time, 0.2 hours. |

Total base time, 10.6 hours.
Previous best record, 15.3 hours.

(c) Automatic screw machine.

| | |
|---|---|
| Handling time, per 100 pieces | 1 hour, 30 minutes. |
| Allowance on handling, 25 per cent | 22.5 minutes. |
| Machine time, per 100 pieces | 7 hours, 40 minutes. |
| Allowance on machine time, 10 per cent | 46 minutes. |
| Total per 100 | 10 hours, 18¼ minutes. |
| Total for one | 6.185 minutes. |

Additional allowances:

| | |
|---|---|
| For tool care | 30 minutes per 10 hours. |
| For set up | 20 minutes per 10 hours. |
| | (Average from experience.) |
| | 50 minutes per 10 hours, or 8.33 per cent. |

$6.185 \times (1 + 0.0833) = 6.7$ minutes each, adopted as standard production time, as a basis for 100 per cent. efficiency.

**392. Changes in piece rates or time standards.** The question of guaranteeing rates and of justifiable changes is an important one in connection with rate setting. The method differs in connection with the nature of the general system of management involved and the distinct compensation system employed.

For example, with straight piecework it is often absolutely necessary, for its success, that the rates be guaranteed for a period of at least a year, as otherwise the operators will hold back in anticipation of a cut.

This condition is caused by the lack of definite knowledge on the part of the management of how long the job really should take when the rate is first established. The earnings of the operator are taken as a gage of the correctness of the piece price; if they are large the price is figured as being too high and a cut follows. Knowing this, the exceptionally skilled workmen naturally do not exert themselves for results beyond the average.

Where rates are guaranteed, it is often under the condition of the methods of doing the work remaining the same. In other words, a changed method would give rise to an opportunity for rearranging the piece price. Sometimes it is difficult to say just what constitutes a changed method, as for example when high-speed steel is used instead of carbon steel, or other changes of even less importance.

Where systems as above described are in use, since their success depends largely upon the confidence with which the management is regarded by the workmen, liberality must be shown in these matters as a necessary part of good policy. A few cents shaved from a piece price often results in upsetting the entire system.

**393. A different view of the matter** can be taken where proper time standards are established as the result of time study. In cases of this kind the rates are established upon facts and any change in facts justifies a change in rates without prejudicing the interests of the workman. This is clearly explained by Carl G. Barth in the American Machinist, vol. 40, p. 124, as follows:

When rates are based upon a complete analysis of every sub-operation performed by the workman and his machine, and a time allowance made for each of these, it becomes a necessity for the perpetuation of the whole method to reanalyze any job that is changed in any particular whatsoever, for any reason whatsoever, be it in a machine operation, or a handling operation, or both.

If then the total time allowance for the new way of handling the job differs from that which formed the basis for the old rate, the rate must be changed accordingly, and whether this is much or little has no bearing on the question.

The difficulty is evidently due to the fact that few managements as yet dictate the feed and speed to be used in connection with each machine operation on a job, and that managers are hence still obliged to make a mere guess at a proper rate reduction or rate increase whenever such changes are made in the material as call for a change in the machine time proper.

Changes suggested by the workman himself do not alter the case, though it goes without saying that he should receive an adequate reward for his suggestions.

This may take the form of his being allowed the old rate for the job for a certain length of time; but if so, his instruction and rate card must show the old and the new rate, together with a clear explanation.

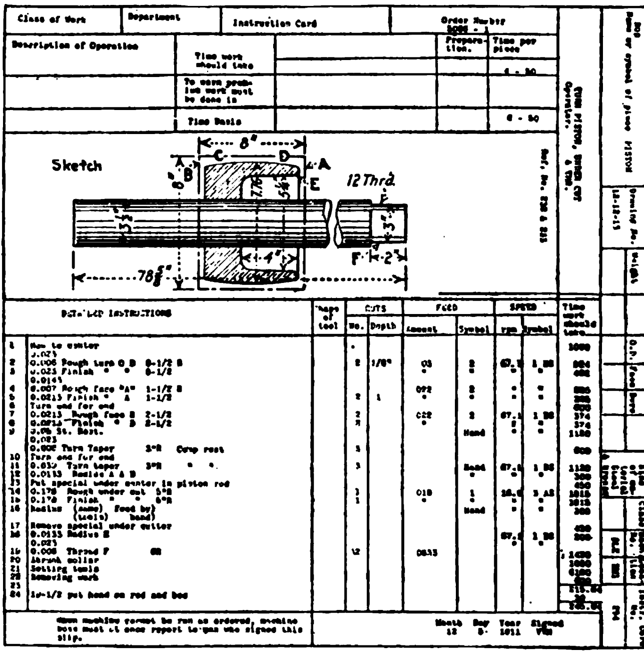



FIG. 208.—Instruction card for a pulley.

## INSTRUCTION AND OPERATION CARDS

**394. Instruction and operation cards.** The results of time study are standardized by means of instruction cards which describe in detail the methods adopted and the time required or that should be

taken for each element. These cards are issued to the operator in advance of the next job, sometimes in connection with the production order or time card and sometimes with the tools when these are delivered to the machine.

Figs. 208 and 209 show two instruction cards used at the Watertown Arsenal. They are the results of careful time study by experienced mechanics, it being the practice at this plant to use only those who have a thorough knowledge of the art for these purposes. The result is that a great deal of detail which would have been added by one less experienced has been omitted, and the items given are combined in such manner as to readily appeal to the practical mechanic.

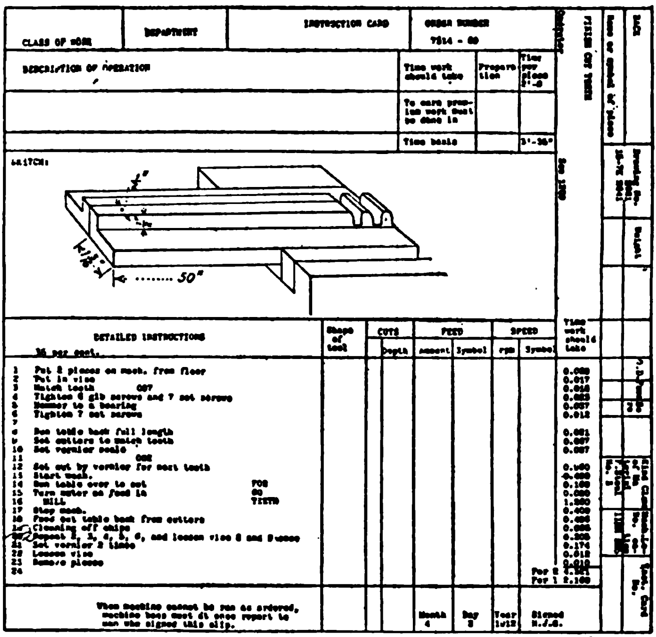


FIG. 209.—Instruction card for a rack.

Fig. 210 shows an instruction card laid out for turret lathe work, and also illustrates the full use of mnemonic symbols. It will be noted that actions are more closely analyzed on this card than on those at the Watertown Arsenal. It would appear that the cards used at the Watertown Arsenal were of a form more likely to get results with the average mechanic, possibly owing to the fact that the mnemonic symbols in the latter case appear to confuse the card, unless one were quite familiar with their meaning.

DM 11

INSTRUCTION CARD FOR OPERATION

Symbol 1 *MV* 1¼ *VZ* 2 *B*

| 1 Sheets, Sheet No. 1 | Drawing No. 7747 | Machine No. *L* 26 | Order No. *MV* 1¼ *V* |
|---|---|---|---|

| Material | Class No. | Pieces in lot | Time for lot | Bonus |
|---|---|---|---|---|

Description of operation.

TURN, CENTER, FORM AND CUT-OFF

| Item | Detailed instructions | Feed | Speed | Element time per piece | Time for entire lot, min. | Continuous on running time |
|---|---|---|---|---|---|---|
| 1 | Change time card | | | | 2.00 | |
| 2 | Study instruction card and drawing | | | | 6.00 | |
| 3 | Put 1½ jaws in spindle | | | | 0.80 | |
| 4 | Put stock in machine, adjust collets | | | | 0.80 | |
| 5 | Set stop for stock in port No. 1 | | | | 0.39 | |
| 6 | Put turning head on turret in port No. 2 | | | | 0.42 | |
| 7 | Put in turning tool and set to turn to 1.245 diam. | | | | 6.00 | |
| 8 | Set stop for turning tool | | | | 0.43 | |
| 9 | Assemble *DSLP* No. 2—*CCC H* ⅜ and *D X S* in port No. 3 | | | | 0.66 | |
| 10 | Put *CC HD* in port No. 4 | | | | 0.21 | |
| 11 | Put *DSG U* No. 2 in front of cross-slide | | | | 2.10 | |
| 12 | Put *PATF* No. 667 in *DSG U* and clamp | | | | 0.75 | |
| 13 | Set stop for *PATF* tool | | | | 1.10 | |
| 14 | Put *PATL* tool in back of cross-slide and set | | | | 0.77 | |
| 15 | Change speed and feed | | | | 0.40 | |
| 16 | | | | | | |
| 17 | | | | | 22.83 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 18 | Turn turret. | | | 0.06 | | |
| 19 | Set stock to stop | | | 0.15 | | |
| 20 | Turn turret. | | | 0.06 | | |
| 21 | Turn body of piece to 1.245 diam. $2\frac{5}{8}$ run. | 0.007 *A* | 336 3*BF* | 1.13 | | |
| 22 | Stop mach. gage and measure | | | 0.36 | | |
| 23 | Turn turret and start machine | | | 0.10 | | |
| 24 | Center end. | *HF* | 3*BF* | 0.25 | | |
| 25 | Turn turret | | | 0.06 | | |
| 26 | Set *CC HD* in center of piece | | | 0.03 | | |
| 27 | Form with *PATF* tool | *HF* | 3*BF* | 2.10 | | |
| 28 | Move *PATL* tool to work | | | 0.03 | | |
| 29 | Cut piece off. | *HF* | 3*BF* | 0.37 | | |
| 30 | Put pc. in tote box | | | 0.06 | | |
| 31 | | | | 4.76 | | |
| 32 | 60 per cent. on handling time 0.91 | | | 0.55 | | |
| 33 | 10 per cent. on machine time 3.85 | | | 0.39 | | |
| 34 | | | | 5.60 | | |
| 35 | Disassemble machine 4.00 | | | | | |
| 36 | Time for lot = (No. pcs. × 5.60) + 4.00 + 22.83 | | | | | |
| 37 | | | | | | |
| 38 | Time for 50 pieces = 30.683 or 5.1 hours | | | | | |
| When machine cannot be run as ordered machine boss must at once report to man who signed this card. | | 6<br>Month | 8<br>Day | 10<br>Year | Signed<br>R.<br>Checked<br>H. | |

FIG. 210.—Turret lathe instruction card.

The use of mnemonic symbols in this connection is sometimes carried to an extreme. Fig. 211 shows the tool list which accompanies the instruction card shown in Fig. 210.

Form DM 17 | Operation symbol
TOOL LIST | 1 *MV* 1¼ *Z* 1 *B*

For machine No. *L* 26. Draw. No. 7746.

Tools called for on this tool list must be issued in a tote box. The list should be placed in the tag pocket on the box and accompany the tools to and from machine.

| Class | No. | Symbol | Size |
|---|---|---|---|
| Chuck jaws | 2 | *CCCA* | No. 3 |
| 2-jaw chuck | 1 | *CCCP* | *L* 16 |
| Facing bar | 1 | *DBP* | 1¾ × 1½ |
| Fin. face cutter | 2 | *DCFM* | 4¼ |
| Rough face cutter | 2 | *DCRM* | 4¼ |
| 4-lip comb. drill | 1 | *DDMS* | 1.488 × 1.238 |
| 4-lip comb. drill | 1 | *DDMS* | 1 7/16 × 1 3/16 |
| Countersink | 1 | *DJB* | 2 in. |
| Fin. countersink | 1 | *DKAT* | 2 in. |
| Sleeves | 2 | *DKCM* | 1¾ × 1½ |
| Countersink stem | 1 | *DKCN* | 1¾ |
| Bushing | 1 | *DKCP* | 1½ × 1 |
| Bushing | 1 | *DKCT* | 1¾ × 1½ |
| Reamer | 1 | *DRAP* | 1½ × 1¼ |
| Floating holder | 1 | *DSHR* | *L* 26 |
| Countersink holder | 1 | *DSLR* | No. 4 |
| Plug gage | 1 | *MGMP* | 1½ |
| Plug gage | 1 | *MGMP* | 1¼ |
| Wrench | 1 | *WFSS* | ¾ |
| Wrench | 1 | *WFSS* | ½ |

| Checks req'd | Man's No. | Hour | Month | Day | 1911 | Signed R. |
|---|---|---|---|---|---|---|
| [redacted] | | | 6 | 8 | | |

When the tool list is not correct the gang boss must at once report the error to the man who signed this list.

FIG. 211.

**395. Operation sheets and diagrams.** These are very closely related to instruction cards, and in fact may be said to be instruction cards applied to machine arrangement. Where the machine set-up is at all complicated it is necessary to accompany the instruction card with a diagram showing the arrangement of tools, chucks, cams, and the like. Some examples of operation sheets are shown applied to Potter and Johnson semi-automatics, Cleveland and Gridley automatic screw machines, and plain turret lathes in Figs. 212 and 213.

*Operation sheets are also used* where time study is not practised, to record the machine set-ups which experience has found best adapted to the work. This saves considerable time and thought each time the machine is reset, and is in line with the principles of standardization. Some makers of machine tools supply pads of blank operation sheets showing a plain diagram of their machine, tool positions, and so on, which are filled in as desired.

**396. Machine-tool diagrams.** The speeds and feeds must be specified for any piece of work when instructions are given regard-

ing the time of completing it. Unfortunately, the speed and feed mechanisms of machine tools even of a similar type are far from being similar. It is quite necessary to have the information concerning these points about every tool in the plant, before much

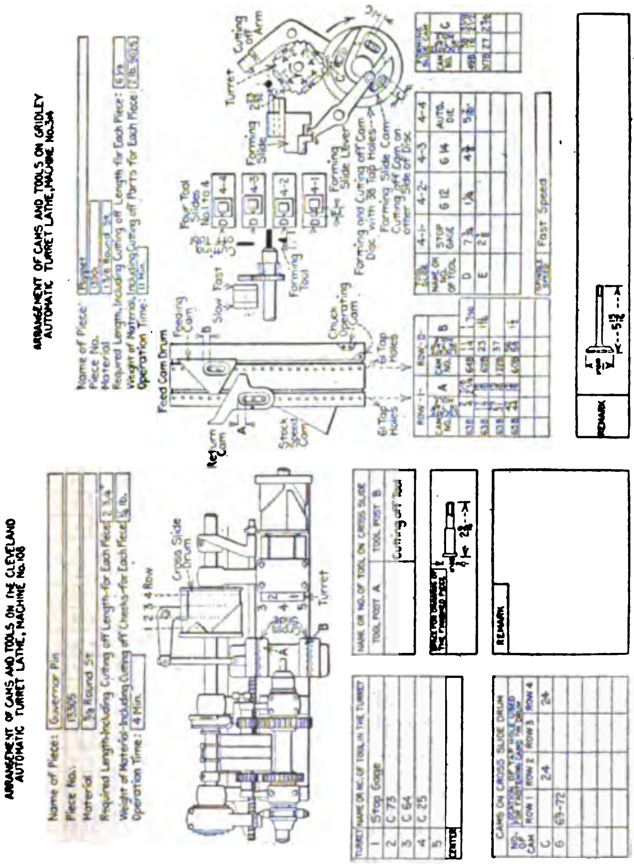



FIG. 212.—Tool set up diagram for bar work on automatics.

can be done in the way of time study. A good plan is to chart the mechanical speed and feed constructions for each tool on separate cards.

**397. Economies effected in the small shop.** The use of time study, standard time allowances, and a compensation system embodying an incentive cannot fail to increase the profits of the

small shop. The time study may not be as elaborate in nature as is usual in the larger plants, and the standard time allowances may often contain errors, but the vital point is that a mark is set and that the tendency resulting is an endeavor to reach it. It is a universal trait to desire to reach or surpass standards, whether in

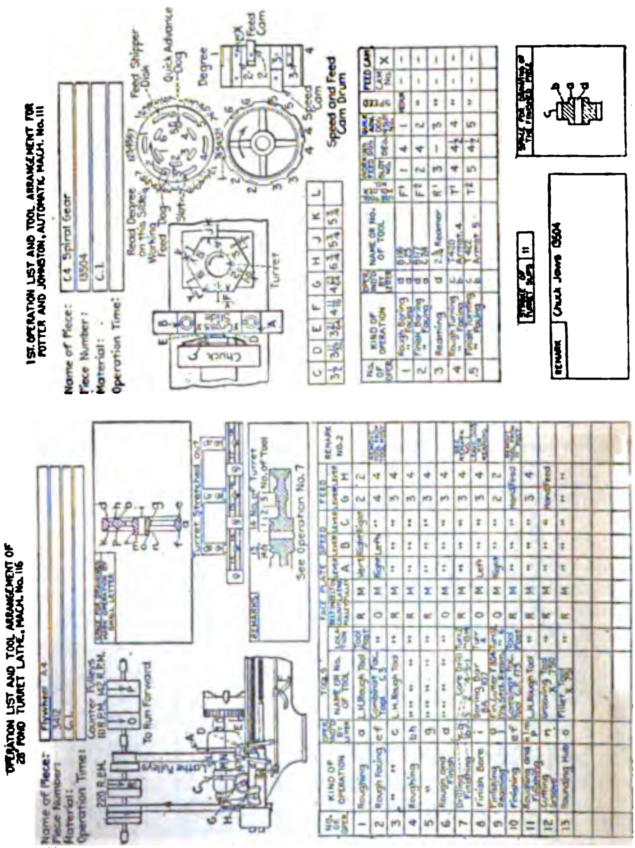
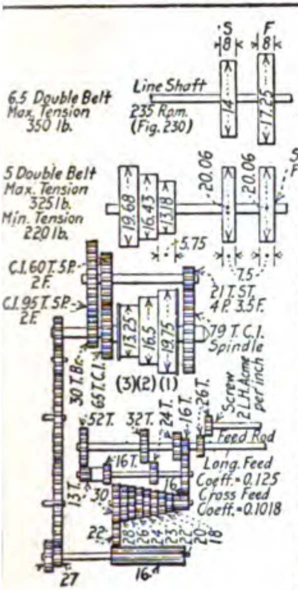



FIG. 213.—Tool set up diagram for chucking work on automatics.

the matter of making new athletic records or in earning a premium. The reason that this trait is not more fully used in commercial and industrial life lies in the absence of definite standards ich is an omission strictly up to the management. The ring extract from the American Machinist, vol. 38, p. 577,




**Reductions**

A = $\frac{79}{21}\ \frac{95}{30}$ = 11.9127 $\quad \frac{A}{B}$ = 3.4305

B = $\frac{79}{21}\ \frac{60}{65}$ = 3.4725

C =

**Cone Ratios**

(1) $\frac{13.48}{20.03}$ = 0.6723   0.3 Allowed for Belt

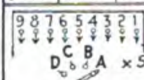
(2) $\frac{16.73}{16.8}$ = 0.9958

(3) $\frac{19.98}{13.55}$ = 1.4745

**Engine Lathe**

**Speed**

| Speed Combn. | Spindle R.p.m. | Speed Combn. | Spindle R.p.m. | Speed Combn. | Spindle R.p.m. |
|---|---|---|---|---|---|
| 1-A-S | 9.14 | 1-B-S | 31.34 | 1-C-S | 108.8 |
| 1-A-F | 11.2 | 1-B-F | 38.5 | 1-C-F | 133.5 |
| 2-A-S | 13.5 | 2-B-S | 46.4 | 2-C-S | 161. |
| 2-A-F | 16.6 | 2-B-F | 56.9 | 2-C-F | 198. |
| 3-A-S | 20.0 | 3-B-S | 68.7 | 3-C-S | 239. |
| 3-A-F | 24.6 | 3-B-F | 84.3 | 3-C-F | 293. |



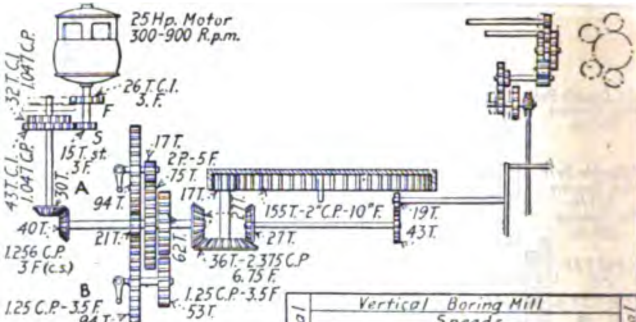

**Feeds**

× Signifies 54 T. Gear on Box
Others 27 " " " "

| Cross | | | | | | | | | | Longitudinal | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feed | Sym. | Feed | Sym. | Feed | Sym. | Feed | Sym. | Feed | Sym. | Feed | Sym. | Feed | Sym. | Feed | Sym. | Feed | Sym. | Feed | Sym. |
| 0.0068 | D9x | 0.0136 | D9 | 0.0272 | C9 | 0.0543 | B9 | 0.10866 | A9 | 0.00833 | D9x | 0.01667 | D9 | 0.0333 | C9 | 0.0667 | B9 | 0.1333 | A9 |
| 0.0073 | D8x | 0.0146 | D8 | 0.0291 | C8 | 0.0582 | B8 | 0.11642 | A8 | 0.00892 | D8x | 0.0178 | D8 | 0.0357 | C8 | 0.0714 | B8 | 0.1428 | A8 |
| 0.0078 | D7x | 0.0157 | D7 | 0.0314 | C7 | 0.0627 | B7 | 0.12537 | A7 | 0.0096 | D7x | 0.0192 | D7 | 0.0385 | C7 | 0.0769 | B7 | 0.1538 | A7 |
| 0.0085 | D6x | 0.0169 | D6 | 0.0339 | C6 | 0.0679 | B6 | 0.13582 | A6 | 0.0104 | D6x | 0.0208 | D6 | 0.0417 | C6 | 0.0833 | B6 | 0.1667 | A6 |
| 0.0089 | D5x | 0.0177 | D5 | 0.0354 | C5 | 0.07087 | B5 | 0.14173 | A5 | 0.0108 | D5x | 0.0217 | D5 | 0.0434 | C5 | 0.0869 | B5 | 0.1739 | A5 |
| 0.0093 | D4x | 0.0185 | D4 | 0.0377 | C4 | 0.0741 | B4 | 0.14817 | A4 | 0.0113 | D4x | 0.0227 | D4 | 0.0454 | C4 | 0.0909 | B4 | 0.1818 | A4 |
| 0.0102 | D3x | 0.0204 | D3 | 0.0408 | C3 | 0.0815 | B3 | 0.16299 | A3 | 0.0125 | D3x | 0.025 | D3 | 0.050 | C3 | 0.10 | B3 | 0.20 | A3 |
| 0.0114 | D2x | 0.0227 | D2 | 0.0453 | C2 | 0.0906 | B2 | 0.1811 | A2 | 0.0139 | D2x | 0.0278 | D2 | 0.0555 | C2 | 0.1111 | B2 | 0.2222 | A2 |
| 0.01275 | D1x | 0.0255 | D1 | 0.05099 | C1 | 0.10187 | B1 | 0.20374 | A1 | 0.01562 | D1x | 0.0313 | D1 | 0.0625 | C1 | 0.125 | B1 | 0.25 | A1 |

| Speed Combination | Pressure x Diameter | Speed Combination | Pressure x Diameter | Speed Combination | Pressure x Diameter |
|---|---|---|---|---|---|
| 1-A | 65,850 | 1-B | 18,930 | 1-C | 5,525 |
| 2-A | 55,060 | 2-B | 15,820 | 2-C | 4,620 |
| 3-A | 44,200 | 3-B | 12,700 | 3-C | 3,710 |

FIG. 214.—Diagram of lathe drive.




| Dial | Vertical Boring Mill Speeds A | B | C | D | E | F | Dial |
|---|---|---|---|---|---|---|---|
| 1 | 0.327 | 0.761 | 1.233 | 2.872 | 6.456 | 15.04 | 1 |
| 3 | 0.359 | 0.837 | 1.356 | 3.159 | 7.102 | 16.54 | 3 |
| 5 | 0.395 | 0.920 | 1.492 | 3.475 | 7.812 | 18.02 | 5 |
| 7 | 0.434 | 1.012 | 1.640 | 3.822 | 8.593 | 20.02 | 7 |
| 9 | 0.479 | 1.113 | 1.805 | 4.204 | 9.452 | 22.02 | 9 |
| 11 | 0.527 | 1.222 | 1.985 | 4.625 | 10.39 | 24.22 | 11 |
| 13 | 0.579 | 1.3444 | 2.184 | 5.087 | 11.44 | 26.64 | 13 |
| 15 | 0.637 | 1.478 | 2.403 | 5.596 | 12.58 | 29.31 | 15 |
| 17 | 0.701 | 1.615 | 2.643 | 6.156 | 13.84 | 32.24 | 17 |
| 19 | 0.775 | 1.766 | 2.907 | 6.771 | 15.22 | 35.46 | 19 |
| 21 | 0.848 | 1.932 | 3.198 | 7.448 | 16.74 | 39.01 | 21 |
| 23 | 0.933 | 2.115 | 3.517 | 8.193 | 18.42 | 42.91 | 23 |

*Constant Reduction*

$$\frac{155}{17} \times \frac{36}{27} \times \frac{40}{30} = 16.209 = C_1$$

*Change Reductions*

$$2^{nd}\ \text{Back Gear} = \frac{75}{17} \times \frac{94}{21} = 19.747 = A_1$$

$$1^{st}\ \text{Back Gear} = \frac{62}{53} \times \frac{94}{21} = 5.2362 = B_1$$

$$\text{Slow} = \frac{43}{15} = 2.8667 = S_1$$

$$\text{Fast} = \frac{32}{26} = 1.2307 = F_1$$


**Feeds**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Longitudinal Feed | Rack | | | | | | | |
| | Sym. | 2 | | 2½ | 3 | 3½ | 4 | 4½ |
| | Feed | 0.0130 | 0.0162 | 0.0195 | 0.0260 | 0.0325 | 0.0390 | 0.0455 |
| | Rack | | | | | | | |
| | Sym. | 5 | 6 | 7 | 8 | 9 | 10 | 12 |
| | Feed | 0.052 | 0.065 | 0.078 | 0.091 | 0.104 | 0.117 | 0.143 |
| | Rack | | | | | | | |
| | Sym. | 14 | 16 | | | | | |
| | Feed | 0.169 | 0.195 | | | | | |
| Vertical Feed | Rack | | | | | | | |
| | Sym. | 2 | | 2½ | 3 | 3½ | 4 | 4½ |
| | Feed | 0.0116 | 0.0145 | 0.0174 | 0.0232 | 0.0290 | 0.0348 | [illegible] |
| | Rack | | | | | | | |
| | Sym. | 5 | 6 | 7 | 8 | 9 | 10 | 12 |
| | Feed | 0.0464 | 0.0580 | 0.0696 | 0.0812 | 0.0928 | 0.104 | 0.128 |
| | Rack | | | | | | | |
| | Sym. | 14 | 16 | | | | | |
| | Feed | 0.151 | 0.174 | | | | | |

| Speed Sym. | Reduction Combination | Total Reduction |
|---|---|---|
| A | $S_1 \times A_1 \times C_1$ | 917.61 |
| B | $F_1 \times A_1 \times C_1$ | 393.965 |
| C | $S_1 \times B_1 \times C_1$ | 243.31 |
| D | $F_1 \times B_1 \times C_1$ | 104.463 |
| E | $S_1 \times C_1$ | 46.466 |
| F | $F_1 \times C_1$ | 19.95 |

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FIG. 215.—Diagram of boring-mill drive.

shows how even the crude and elementary use of these principles resulted in profits for a small shop in England.

*Speeding up a small shop.* A rather interesting example of what may be done in speeding up a small shop is contained in the following extract from the personal experience of one of the owners.

We started business some 16 months ago as a limited company, the business already being established by one of the partners. Our capital is not large and is divided into common and preferred shares, the latter being preferential as to 7 per cent. The common shares are all held by the partners.

At present our employees number 18, made up as follows: 1 foreman, 6 machinists and fitters, 1 stockkeeper, 1 clerk, 1 outdoor representative and 8 apprentices, none of the latter having been with us much over 12 months.

Our work consists mainly of machining parts for the automobile trade, one or two specialties of our own, a small amount of automobile repairs, and during the fishing season marine oil engine work.

Our balance sheet for the first 12 months shows that we have paid 7 per cent. on both the preferred and common shares, have allowed generously for depreciation, and in addition divided among our employees an amount equal to 5 per cent. of the wages and bonuses earned by them during the period.

Our system briefly is as follows: The number of pieces we handle of a kind may vary 6 to 500, but no matter how large or small the order, it goes through the shop on the bonus system. For example: A customer sends in an inquiry and blueprint for quotation. The point is carefully studied and each operation laid out in a loose-leaf binder, together with the necessary time, cost of material, and the like, and indexed under the customer's name. This binder is called the estimated cost book. Should the order be secured a production order is made out by the clerk and the operations and times copied from the estimated cost book into a similar one known as premium bonus times, from which it is copied again on premium bonus tickets.

The production order, the necessary blueprints and the bonus tickets are then handed to the foreman who files them in a rack until he is ready to begin the job. Now comes the most important point of the system, that of seeing that the work is done in the time specified on the bonus ticket. It is the foreman's duty to see that each operation is performed expeditiously with minimum tool charges, and to encourage the operator to use his brains more and his hands less.

Naturally the first time a new piece of work passes through the shop there is bound to be a kick or two against the time allowed for the various operations; it is then the foreman's duty to demonstrate to the employee that not only can the operation be done in the time specified, but in less, thus insuring a bonus to the worker.

Occasionally the job cannot be done in the time specified in which case either the time can be increased or, since the maximum speed at which the casting can be machined is the same no matter who does the job, it can be given to an operator whose lesser rate balances the increased time allowed, or in other words brings the labor cost to the same figure as originally fixed. Increasing the time, however, is discouraged, as difficulties can always be overcome and the job turned out at a profit by improving the methods of going about it.

The job being finished, it is sent to the inspection room together with the production order, on which the foreman has entered the necessary notes as to the number of pieces, the operations, and the operation number. The drawing or blueprint and the bonus ticket are also sent in with the work. The inspector having examined and passed the job, the bonus ticket is initialed and sent to the pay office.

If an operator does not make a bonus, the foreman has to explain why, and if the fault does not lie with the workman, the ticket is passed but the difficulty is noted for correction the next time round. The losses are deducted from the gains and the balance paid over to the employee at pay time. We treat each week on its own merits and do not carry the losses of one week into the next.

Another important point is that we never cut a time once fixed, unless new appliances or machines are introduced, or a set of operations previously done by one man is divided among several. We do a fair amount of work where the number of pieces to be machined are few, and in some cases single pieces. In such cases the job is still put on bonus, but naturally the time allowed is greater, and the price to the customer is more.

It might be thought that it would not pay to issue bonus tickets for one piece, but the great advantage is that it keeps up the interest of the worker in his job and enables him to make bonus on one piece just as well as on a number. Then, too, the work is generally such that it involves say turning, marking out, drilling and tapping. One ticket will then do, each operator booking his time on it and one man being paid the bonus, who in turn shares it with the other men whose efforts have contributed to its success.

Almost without exception, we give a price beforehand for every job, whether for machining a number of pieces or repairing an engine in a boat, and in the latter case it pays to use the bonus system. All the machining jobs can be given to one man and the fitting, erecting and testing to one or two more. Thus an inducement is given to treat the job as important and not as a "hospital" job.

This system may seem complicated, but when we mention that all our machining is done to Newhalls limits and that one man does practically all the estimating, makes all the drawings of jigs and tools for customers' orders, writes out all the bonus tickets, performs the duty of shop superintendent, and in addition handles half the correspondence, besides superintending outdoor jobs, it will be seen that there is not such a mass of clerical work. It should be mentioned that our clerk has nothing to do with the bonus system, beyond making out the production orders.

**398. The value of demonstrators as teachers.** Shop demonstrators have their field of usefulness, and although they are not always desirable in the matter of rate setting, they are especially valuable in training new men, a task that the ordinary foreman is unfitted for both by disposition and for lack of time. A demonstrator and an instructor are about one and the same, except that the latter term is usually applied to one who instructs apprentices.

*A demonstrator in this sense is not* necessarily a speed boss, although he may have something to do with speeds and feeds in the matter of showing how a job should be handled. He should be a real mechanic, something that is rather hard to find, which is further argument for his usefulness, as the average machine operator is rather deficient in this respect.

Especially where tooling and machine operations are not standardized, a man who can show the operator the best way to set up for the job at hand, the proper way to grind the cutting tools, the quickest and most accurate way to chuck or make fast without spring or distortion, and other points which come through skill and experience, is a valuable man. The difficulty is to find one whose knowledge applies to a variety of machines equally well.

In the large shop, a demonstrating teacher may be employed to look after one class of machines; in the small shop this is out of the question. On the other hand, in the small shop a demonstrator is not so much needed, since new men are not broken in so frequently, and the foreman is usually more or less of an all-round mechanic and has more time to apply to these matters than the foreman in the large shop.

The small shop, however, can take advantage of the practice of the machine-tool builders in sending out demonstrators on various machines. The makers are glad to extend this service to the small shop having one or two machines, in the expectation that some day they will require more, especially if the small plant is so located that the demonstrator can kill two birds with one stone and *make his visit* in connection with visits to other plants. It is *therefore good policy* for the small shop to put itself on record with

machine manufacturers who send out demonstrators that such service is desired when they are in the neighborhood.

## COMPENSATION AND WAGE METHODS

**399. Compensation methods.** Compensation systems must be regarded from several points of view: first, as to their effect on the cost of production; secondly, as to their effect on the workmen and also the feasibility of applying the particular compensation scheme to the work involved. In a great many cases, too little consideration is given these points before attempting to install a special compensation scheme.

**400. Necessity of equalized machine capacity for successful bonus or piece payments.** With any system of wage payment based on the output, the efficiency of the machine worked upon is a large feature in limiting the earning capacity of the operator. An old machine which is inferior in design, strength, and condition of repair could not be expected to compete in production with a modern new machine particularly suited for the job. Neither would it be feasible to make different rates, or set different standards according to the nature of the machine on which the work is done. C. G. Barth says in this connection (American Machinist, vol. 36, p. 54): "I have found that *with machines of the same class, differing in their speeds, feeds and power, a just and efficient premium or piece rate system is an impossibility.* The universal failure of such systems in the past is in part traceable to a lack of appreciation of this fact." This would seem to limit the successful installation of such systems to plants in which the machine-tool equipment was pretty well standardized, at least those on which this class of work is attempted.

**401. The following descriptions** of existing types of wage systems are in large part taken from an article by C. B. Auel, Director of Standards, Processes and Materials, Westinghouse Electric and Manufacturing Co., which appeared in American Machinist, vol. 36, p. 945. The comparison table is also from the same article.

**402. Daywork.** Daywork is the oldest recorded form of wage payment. It is also probably the most extensively employed at the present day, and in some plants it seems to be the only practical one. The fact that daywork does not necessarily mean high cost is evidenced by the fact that the Ford Co., of Detroit, employs this system exclusively, their recent addition of profit-sharing methods having nothing to do with the efficient results which were formerly obtained by daywork but coming as a result of them.

While the ordinary administration of daywork offers no incentive to an increased production, under good management, where accurate records of the work are had, a strong incentive may be presented in the matter of wage increases. Also there is no reason why standard operation times cannot be set under the daywork system as well as under any of the others. If these standard time records are set to represent average skill performances, those workers who exceed them are justified in receiving rates above the average, while the reverse is true regarding those who fall below.

While daywork may thus be made to offer an incentive to the workman in the matter of ultimate wage rate attained, the incentive

is not automatically applied as in some of the special compensation systems described, and due to oversight or neglect on the part of the foremen and superiors, men are not in general rewarded in direct proportion to their skill and efforts. If this were true the variation of day rates in the average shop would be much greater between the least skilled and the most skillful.

The advantages of daywork are rather negative in nature, consisting in the small expense and simplicity of maintaining the payroll, and the supposedly higher quality of the output which is sometimes said to eliminate inspection expense. The disadvantages are that the natural tendency is for the workmen to deliver only such daily efforts as will satisfy their immediate superiors and hold down the job; a general reduction in production capacity below normal possible capacity results, as evidenced by the fact that in setting piece rates daywork records are considered at 65 per cent. efficiency or even lower. And as far as figuring labor costs is concerned, daywork methods are more complicated than piecework. The expense of proper supervision is greater, due to the lack of incentive.

Where no two pieces are alike, such as in die work, jig or template making, pattern work, and in repair work or other work where the necessary time may vary considerably, daywork payment is the only logical scheme to use. Any other compensation system would require preliminary work in figuring the probable time required which for such jobs would cost more and take longer than the time required to do the job.

To get the best results from daywork, the aim should be to make wage adjustments on the basis of recorded performances, and this necessitates an accurate system for recording time.

**403. Straight piecework.** This is the oldest of the "direct incentive" systems. Payment is based solely on the number of pieces multiplied by the price per piece. Next to daywork it is the most extensively used compensation system. The rate of the workman rises in a vertical line. The direct labor cost saving all goes to the man who makes it under straight piecework, but the firm gets the benefit of the increased production and the consequent lowering of the overhead charges per piece. Owing to this feature, the difficulties are met which have given piecework a somewhat undesirable name. If the rate is set too high, as is the case in the majority of plants when piecework is first installed, the employee derives far more benefit from it than the firm. This results in price cutting which has an immediate tendency to limit the workman's efforts to an amount of output which will not give rise to a cut. In the majority of piecework plants, therefore, there is a distinct tendency, well understood by all operators, to protect their prices by nursing the good jobs. On the other hand, if the prices are set low to begin with, fair wages are only obtained by the exceptionally skilled. So that the proper working of the straight piece system requires a closer and more accurate knowledge of the proper time that should be spent [illegible] operation than any other with the exception of "Task Work." [illegible]ience has shown that if piecework is to be a success, low [illegible]t be raised, but that high prices cannot be lowered unless

the method of making the piece is changed. This is modified in some plants by guaranteeing all rates for a period of from 1 to 2 years, which has the same effect.

Among the disadvantages of straight piecework, aside from the difficulties in price setting mentioned above, is that it fails to take account of the varying price of labor. Thus when business is good, men may prefer high day wages in another shop to the harder work of the shop in question, and when times are bad, the manufacturer cannot take advantage of the lower day rates offered by his competitor. Also it is possible with daywork, and premium or bonus, to manipulate the costs somewhat according to the rate of the man engaged on the work, whereas with straight piecework the price is fixed regardless of the rate and skill of the man employed.

The advantages of piecework over all other systems is the simplicity of securing costs and making up pay-roll records; also the fact that the manufacturer knows definitely in advance just what his work is going to cost for direct labor.

Piecework can be well applied to classes of work in which the degree of skill does not become a large factor, where the prices are set properly at the start, and are guaranteed for a period.

One great drawback lies in the fact that the workman is not assured of a minimum day's pay, and the difficulty of making proper allowances for factors beyond his control, such as hard castings, loose belts or other things which hinder his producing as much as he might otherwise do.

**404. Manchester piecework system.** This is a scheme intended to avoid the uncertainty of a minimum day's pay which accompanies straight piecework, by the guaranteeing of a daily wage based on a day rate which is fixed at the time of employment. Sometimes these guarantees hold good only for delays and stoppages beyond the control of the workman, and sometimes are extended to cover all delays. This system is open to the other disadvantages stated for the straight piecework system, and also has the advantages which accompany it. The guaranteed rates must be made fairly low, however, or it will be found that some workmen prefer to fall back upon them too frequently, raising their average of pay on those days when they have an "easy job."

**405. Taylor differential piecework.** This is a piecework system devised by F. W. Taylor, and consists of two or more prices being set upon the same job, the maximum price being allowed when the piece is done within the minimum time, and the smaller price being given when this time is exceeded. The idea is to furnish a spur toward the attainment of the highest possible labor efficiency, and with this in view, the time limits are set so that only the most skillful can reach the maximum rate, thus driving those who are not adapted for the particular class of work into other operations for which they are better fitted. There is a sudden advance in hourly rate between a job finished in the minimum time and when this time is exceeded.

This system is straight piecework with a double rate, and is open to the same objections as those applied to single-rate piecework, together with the additional complexity of a double set of prices.

However, since this system has almost invariably been applied in connection with the Taylor methods of time study by which data are collected which lead to the proper rates being set, it has, when applied, started under more favorable conditions. *Close time study is coming to be found a necessity in connection with any of the special methods of compensation*, and consequently is no longer the distinguishing feature of this one.

**406. The group method.** The group system of wage payment was installed several years ago at the Westinghouse Electric and Manufacturing Co. and given a thorough trial. Earnings of the group in comparison with individual earnings before were as follows:

**407. Methods of operating group system.** (*a*) A number of workmen, not exceeding 12, are grouped together under a working charge hand.

(*b*) The charge hand sees that the tools of his group are always in working order, keeps his men at work and properly supplied with materials, sees that the quality of work is of uniform standard and assists in increasing the output when not otherwise engaged.

(*c*) A limiting or maximum price is set on each piece of apparatus, the total earnings of the group being equal to their total day-rate wages for the time employed, plus one-half the difference between such wages and the limiting prices on the pieces completed; in no case, however, are the limiting prices to be exceeded.

(*d*) The earnings of each individual in the group are a proportional share of the total earnings, based on his hourly rate and hours worked.

(*e*) Defective work (labor) is not paid for, though the company should stand any loss of material resulting therefrom.

(*f*) No individual time slips are issued, each workman's attendance being ascertained from a checkboard or the equivalent, upon which he must register daily before commencing work.

(*g*) Individual merit is recognized from time to time by an increase in the hourly rate.

(*h*) As an incentive to strive continually toward a lower cost, the group may be awarded an additional bonus whenever their earnings exceed their day-rate wages by some previously determined percentage.

(*j*) Labor costs are approximated by proportioning the wages paid in any given period among the various pieces, on the basis of their respective limiting costs.

**408. The advantages given for this system** are a reduction in defective work; the elimination of overrun limits, common to the premium system; the elimination of individual time slips and the labor connected with them; increased supervision without extra expense; coöperation between members of the group with the elimination of soldering; simplification of count, it being necessary to count only the group output; simplification of inspection for the same reason; and an increased output.

**409. Contract work.** Contract work does not seem to be as widely used as it was a number of years ago. The method of using it differs widely, ranging from a contract given to a foreman or individual for the completion of a machine, usually the assembling

operations, to contracts with individuals which border on the piecework system. In the former case, the individual having the contract may have a large number of men working for him. Their rates are set by the foreman; the company usually finances the arrangement, paying the men according to this rating and charging whatever is paid out against the price on the job. There are many disadvantages apparent in such a method, chiefly the fact that the men do not receive uniform treatment, this depending on the nature and cupidity of the man having the contract. As observed in one shop where the author had opportunity to see this system extensively used, the subordinates were paid in many different ways by the different gang bosses having contracts, the most successful on the whole being one gang where the foreman made a practice of dividing his profits among the men over and above a certain amount. To have such a variety of compensation methods as this gives rise to existing in any one shop is bad policy, and in connection with the growth of unit assembly has been a large reason for the lessening of its application.

**410. Premium or bonus systems.** Daywork takes account of time but not of quantity in figuring earnings; piecework neglects time but calculates on quantity only, and premium or bonus takes in both elements, paying a premium or bonus when a given quantity is completed in less than standard time, or when a larger quantity than standard is completed in a given time. One feature of all bonus or premium plans is the guaranteeing of a minimum day rate.

**411. Halsey premium plan.** This is the first premium plan on record, being devised by F. A. Halsey in 1890. The original scheme consisted in giving the workmen premiums equal to one-third or one-fourth of their hourly rates for the time saved over past performances. This has been modified so that, as commonly used at present, a standard time is selected for the given operation after careful study of the prevailing conditions, which is known as the base or standard time. There is then added to this figure, which represents the length of time the work should be completed in by average skill and industry, an extra amount, the sum of the two forming the time limit or time allowed. If the workman completes a job in less than the time allowed, the saving is divided between him and the firm. The proportion in which this is divided varies from 20 per cent. to the operator and 80 per cent. to the firm to an equal division to each.

The amount which is allowed over and above the base time in arriving at the allowed time depends upon the conditions surrounding the work; for example, when there are good facilities for finishing the job, in a clean and comfortable shop with plenty of light, the allowance would be less than for the same job performed in a dark shop with less comfortable working conditions. Thus a similarity in the base time of two jobs does not necessarily mean that the time allowance will be the same for each of them. It is, however, usual to guarantee that time limits which have been set will not be reduced, and also to make the same guarantee with respect to the day rate of the operator, on which his premium is of course based.

**412. The disadvantages of the premium system** lie in the fact that while the effort per piece increases with a large output, the workman receives less and less for each consecutive piece per unit of time produced, which means that sooner or later the workman will find an output which gives him the maximum return for the amount of energy expended, which may not be, however, the maximum output which he would reach under another compensation scheme. It also requires more clerical labor to maintain the records and reports than the piecework systems.

**413. The advantages of premium compensation are as follows:** The operator is assured of his minimum day rate. This is particularly effective at the start as it prevents discouragements through small earnings before skill is acquired. In many piece-rate shops, new workers are given a week or two at daywork at the start. Their rate, however, is of necessity set low, and the method is not an equable one since some acquire skill faster than others without, however, proving better workmen in the long run.

Premium gives the firm a larger percentage of the total savings, due to the fact that under this system the more the man makes, the more the firm gains, whereas the gain to the firm under piece rate is substantially a fixed amount and the initial price is made low to make this as great as possible.

If affords more protection and a better rate to the slower workmen. The rate of decrease of earnings under a premium system is not as abrupt as under piece rate. This is in favor of the average degree of skill, whereas piece-rate payment favors the exceptionally gifted.

Due to the general impression among workmen that the piece system is accompanied by continuous price cutting with increased production, the premium system with its stationary standards is not met with the same initial prejudice. While possibly due more to incorrect application of the piece system, the absence of this objection and the feature of a guaranteed day rate make it an easier system to install as far as the workmen are concerned.

In addition to the above, premium plans which allow of varying hourly rates give the opportunity to effect cost reductions by the manipulation of operators, it being possible where cost reductions are necessary to train new operators with lower hourly rates to do the work, without making any cuts in the allowed time or premium percentage. And fluctuations in the labor market are also automatically met by this system which avoids one of the principle objections of piecework schemes.

**414. Rowan premium system.** This is a modification of the premium scheme in which time allowance is made in a similar manner to the Halsey plan, but the premium instead of being figured as a definite percentage of the time saved is figured by multiplying the time actually taken by the ratio of the time saved to the time allowed. For example, suppose a job which had a time allowance of 8 hours was finished in 4 hours. The premium allowed would be $4 \times \frac{4}{8}$ or 2 hours, the wages being the day rate multiplied by 6 hours instead of 4. In this case, the premium would be similar to that earned by an operator making the same time

and with the same time allowed, under a 50 per cent. Halsey premium plan. However, suppose that the allowed time had been far too great, and the operator finished the job in 2 hours. The premium would be $2 \times 6/8 = 1\frac{1}{2}$ hours, which would correspond to only 25 per cent. under Halsey plan.

This is *the feature of the Rowan plan*, which was designed to protect the manufacturer in cases where the time allowed was too great. However, since the majority of cases will certainly come closer to a proper time allowance than either of the two examples here given, and since the premium increases in percentage amount as the time taken approaches the time allowed (though not in total amount), the costs under this plan are really higher on the average than under the Halsey plan. There is also the disadvantage with this system of the somewhat complicated method of arriving at wages, which makes it difficult to explain to the workman the basis of his pay and is therefore quite likely to give rise to misunderstandings about the contents of the pay envelope which is one of the most serious sources of trouble between the management and the men.

**415. Task and bonus system.** This was originated by H. L. Gantt, and consists of a standard task, figured by time-study methods, and a substantial bonus allowed the workman when this task is equalled or excelled. The standard is set high under the same principle as that of the Taylor differential piecework system, so that only those fitted for the particular work and consequently the most skillful at it will be able to earn the bonus. Those who fall below the standard task are paid a day rate which is usually set low enough so as not to hold out much inducement to those unable to attain the skill. The foreman under this plan is given a bonus for every workman who earns a bonus, and in addition another reward when all of his men earn bonuses.

The advantages of this scheme, after the standard times for the various jobs are figured, lies in its simplicity of figuring wages, also in the extra inducement held out to the foremen. The disadvantage, if it may be called so, lies in the amount of labor necessary to arrive with accuracy at the standard tasks, and unless this is accurately done, the results are without value.

**416. Emerson efficiency system.** As originally planned, a standard time was allowed for the job; the man completing the job in this time would be allowed a bonus of 20 per cent. If he took longer than standard time to complete the work he would still be paid a premium, but a diminished one, receiving none at all when his "efficiency" dropped to the 80 per cent. mark. On the other hand, when his "efficiency" went above 100 per cent., as evidenced by his finishing the job in less than the standard time, the bonus correspondingly increased.

This scheme proving a little too one sided, in favor of the workman, a modified scheme was adopted in which the premium is figured on the time taken instead of on the time allowed. This naturally diminishes the premium which goes to the workman, a part of the saving going to the firm. The 20 per cent. premium percentage is still retained for work finished in standard time.

The "efficiency" of the workman, or in other words the ratio of the standard time to the time taken, plays an important part in the Emerson plan. It is not only figured on individual jobs, but may be figured on all the jobs completed by the same man in a given period, thus giving, for example, individual monthly or weekly efficiencies, or it may be figured for a group of individuals or for a whole department.

**417. A variable quantity piecework plan.** To overcome the difficulty encountered with piecework as applied to small and variable lots, the author devised and used a plan in which the price was composed of two elements, $P$, representing the preparation time, or the time required to set up the machine and get things ready, and $O$, which is based on the actual time required to do the work. The quantity $P$ is independent of the quantity made, being done once and only once, whereas $O$ is applied to each piece. Suppose, for instance, that 15 cents is the price allowed for setting up the machine, and 5 cents is the price allowed for each piece. If 1 piece only were finished, to take an extreme case, the price would be $15 + 5 = 20$ cents. If 10 pieces were finished, the price would be $\frac{15 + (10 \times 5)}{10} = 6\frac{1}{2}$ cents. If 100 pieces were finished at one set-up $\frac{15 + (100 \times 5)}{100} = 5.15$ cents.

Thus *the cost of the individual piece varies with the quantity*, becoming cheaper with large numbers. If the relation between set-up allowance and operation allowance is correct, it is not a hardship upon the employee to be asked to finish small quantities, and on the other hand the price will adjust itself for large quantities. In plants where production is well standardized as to lot sizes there would be no advantages shown, but it has proved of use on small and variable lots, and may be of benefit to the small plant where these are usually found.

**418. Profit sharing.** There are many different schemes of profit sharing, which cannot be classified as a compensation plan, since it is entirely additional to the general wage system. *Profit sharing may exist in connection with any of the above plans of compensation.*

The most widely discussed is that of the Ford plant. A list of eligibles is prepared and extended and revised by an investigating committee comprising about 100 individuals, who look up all facts regarding the employee both within and without the plant and make their report. If it is favorable, he will receive a portion of the $10,000,000 which has been set aside as this year's appropriation for that purpose in the form of a weekly addition to his pay envelope. The division is made in such manner that the lower-rated employees receive the greatest percentage amounts. The man who formerly received from 23 to 38 cents per hour is eligible to a share which will bring his daily earnings up to $5. Those who received from 38 to 48 cents, are eligible to a portion which will bring their total daily pay up to $7. This plan has hardly been in use long enough to pass upon its results or feasibility as a continued proposition.

The Yale and Towne Co. at one time used a profit sharing plan in which an average cost per unit was determined, and used as a criterion of cost for a given period. Any savings made were divided on the basis of 50 per cent. to the company, 40 per cent. to the workmen, and 10 per cent. to the foremen. This has since been discontinued.

**419. The Lodge and Shipley Co.** are using a premium system of compensation among the producers, and in addition have a profit sharing plan in force for the benefit of the non-productive departments. Fifty per cent. of the time saved goes to the workmen, 25 per cent. to the foremen, and 25 per cent. to the non-producers. The awards under this scheme are made monthly.

It would seem that a profit sharing scheme which divides a sum annually among its employees is not likely to be of any great benefit to the firm using it, due to the remoteness of the reward. The average man wishes to see the results of his work placed before him in dollars and cents, within a week or a month at least, and cannot look forward for a whole year with much enthusiasm. And those plants in which profit sharing is successful, or promises to be, have taken account of this fact and made more frequent divisions.

**420. Bonus to foremen.** The effect of a bonus to foremen in increasing their efforts toward economy, efficiency, and a larger output has resulted in many firms adopting bonus plans or other systems of reward for these individuals. Where a premium or

| Hours worked | Daywork | | Straight piece | | Differential | | Emerson (mod.) | | Emerson (orig.) | | Rowan | | Gantt, 50 per cent. | | Halsey, 40 per cent. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wages | Hourly rate | Wages | Hourly rate | Wages | Hourly rate | Wages | Hourly rate | Wages | Hourly rate | Wages | Hourly rate | Wages | Hourly rate | Wages | Hourly rate |
| 7 | 1.68 | 0.24 | 1.152 | 0.164 | 0.96 | 0.128 | 1.68 | 0.24 | 1.68 | 0.24 | 1.68 | 0.24 | 1.68 | 0.24 | 1.68 | 0.24 |
| 6 | 1.44 | 0.24 | 1.152 | 0.192 | 0.96 | 0.15 | 1.44 | 0.24 | 1.44 | 0.24 | 1.44 | 0.24 | 1.44 | 0.24 | 1.44 | 0.24 |
| 5 | 1.20 | 0.24 | 1.152 | 0.230 | 0.96 | 0.18 | 1.239 | 0.248 | 1.239 | 0.248 | 1.40 | 0.28 | 1.20 | 0.24 | 1.296 | 0.259 |
| 4 | 0.96 | 0.24 | 1.152 | 0.288 | 0.96 | 0.36 | 1.152 | 0.288 | 1.152 | 0.288 | 1.28 | 0.32 | 1.44 | 0.36 | 1.152 | 0.288 |
| 3½ | 0.84 | 0.24 | 1.152 | 0.328 | 1.44 | 0.411 | 1.128 | 0.322 | 1.152 | 0.329 | 1.19 | 0.34 | 1.44 | 0.411 | 1.08 | 0.308 |
| 3 | 0.72 | 0.24 | 1.152 | 0.384 | 1.44 | 0.48 | 1.104 | 0.368 | 1.152 | 0.384 | 1.08 | 0.36 | 1.44 | 0.48 | 1.008 | 0.336 |
| 2 | 0.48 | 0.24 | 1.152 | 0.576 | 1.44 | 0.72 | 1.056 | 0.523 | 1.152 | 0.576 | 0.80 | 0.40 | 1.44 | 0.72 | 0.864 | 0.432 |
| 1 | 0.24 | 0.24 | 1.152 | 1.152 | 1.44 | 1.44 | 1.008 | 1.008 | 1.152 | 1.152 | 0.44 | 0.44 | 1.44 | 1.44 | 0.720 | 0.72 |

Time limit = 6 hours; standard time = 4 hours; workman's rate = 24 cents per hour; piece prices = \$0.96—\$1.152—\$1.44.

FIG. 216.—Comparison of Wage Systems

bonus system of wage payment is in effect this is something that may be easily extended to the foremen as a percentage on the premiums or bonuses earned in their departments. The Lodge and Shipley Co. of Cincinnati, Ohio, operate a scheme of this kind. The productive foremen are credited with a bonus of 5 cents per hour for every hour which is saved from the allowed time, and debited with 20 cents per hour for every job that overruns the time limit, the difference between the two constituting their bonus.

In plants which have not reached the point of standardized time records which permit of productive efficiency being easily measured, the plan of distributing a bonus to foremen is a more difficult one. Something must be used as a measure of department efficiency to arrive at a fair division between the various heads, and in addition it is a question of difficult solution to determine the total amount to be divided. This proposition is clearly outlined in an article by C. B. Lord, of the Wagner Electric Co., which appeared in the American Machinist, vol. 41, p. 96, and which described a foreman's bonus scheme which his company have operated for the last 5 years. The following are extracts from his article:

"*There is little merit in any system that makes the giving of premium merely a gift from the management.* To be effective and fair, it should be based on merit, and should differentiate between the good foremen and the poor ones. To do this, it must be based upon records of shop operations, and profit and loss.

"*Whether the bonus shall be paid monthly or yearly is dependent upon the records kept.* In concerns where it is easy to keep a perpetual inventory, and departmental efficiency records, it is possible, and probably best to pay a monthly bonus, which has in its favor the fact that it is not too far in the perspective to be efficient as an incentive.

"The monthly bonus has against it the fact that it must be, generally speaking, an approximation, based on theoretical efficiency as exact figures as to the amount of profit or loss are not available until the yearly balance is struck.

"While the method of arriving at the bonus should be definite, it should not include too many factors, but as before stated, there should be sufficient to distribute the bonus according to the ability and responsibilities of the men.

"Whether both productive and non-productive foremen should participate in the bonus, is a question which each executive must settle for himself. Personally, I take the view that the non-productive foremen are entitled to bonus, but not in the same degree as the productive foremen. The system outlined takes care of this factor. The line between those who shall receive bonus, and those who shall not, should be well defined. There must always be a certain number of men who do not participate and to whom a bonus would not mean increased efficiency. It would merely be a gratuity, and would have a tendency, in my estimation, to spoil the effect of the earned bonus. *Any system founded on equity is bound to affect someone adversely.* The best we can do is to do the least harm to the fewest number.

In inaugurating a system, instead of laying it out first and then ching for facts to substantiate it, it is better to take the records

for several years, and analyze them carefully, searching for factors that are most affected by business conditions, and those most affected by shop conditions, and the efficiency of the foremen.

The method I worked out some 5 years ago, and which has been used with apparent satisfaction since, is based upon six factors, five of which are fixed, and one arbitrary, as follows:

(*a*) *The base is a percentage of total factory savings*, in labor and material, over the estimates for the year. The revised or standing costs for the preceding year being the estimates for the current year, so that this factor determines the efficiency of the shop as a whole, and all foremen, whether productive or non-productive, participate in this base figure.

(*b*) *A percentage of departmental savings divided by the number of foremen in the department.* This item differentiates between the efficiency of the factory as a whole, and the efficiency of the different departments, due generally to the efforts of the individual foremen.

In arriving at the share of the foreman of any department that serves the entire or most of the factory, such as the punch shop, the average of the amount paid foremen of all departments which they serve is taken.

(*c*) *Percentage of monthly salary.* This item takes care of the different grades of salary and executive responsibility.

(*d*) *Percentage of average number of men supervised*, in round numbers of 25, 50, 75, and 100; departments having less than 25 are not considered.

(*e*) *Per cent. total pay-roll is less than 50 per cent. of the total productive output.* With some firms, this might be an uncertain factor, but at the time this system was inaugurated, in looking over the yearly reports for several years back, it was shown that some years the total pay-roll, including expense, exceeded 50 per cent. of the total productive output, reckoning in labor and material only, and in other years it was less. This means that in outlines, material and labor are about even. This item would have to be varied to suit conditions, or eliminated. I, however, considered it important, and decided to call 50 per cent. a normal year, and take this as the fifth factor, paying $1 for each per cent. that the pay-roll is below. This item creates an interest in keeping the pay-roll, expense, help, and the like, down, and makes departments careful of spoiling or scrapping material. It also tends to offset item 4.

(*f*) *Departmental improvements.* This is arbitrary and takes into account the mechanical efficiency of the department, including any improvements made during the year. As to the amount of premium, this must depend both upon the generosity of the management and the character of the work done, but the main thing is that it be earned. I believe that the giving of a gratuitous compensation is harmful, as the foremen come to learn that they will get it no matter what the condition of business or their respective departments may be. I also believe that it should depend upon profits made.

I submit the records of three years—1910, 1911 and 1913. (See Fig. 217). It will be noted that in the case of A. C. the bonus was considerably less in 1911 than in 1910, due to losses in his department.

| | ABG | AC | ADT | AE | AF | AD | AN | BHM | BJP | BLR | BMS | BPM | BKP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Per cent. of total saving | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 |
| Per cent. of departmental saving divided by number of foremen. | 10 | 18 | 7 | 10 | 10 | ..... | 10 | ..... | ..... | ..... | ..... | ..... | ..... |
| Per cent. of monthly salary | 28 | 28 | 25 | 22 | 24 | 25 | 23 | 20 | 25 | 17 | 16 | 21 | 18 |
| Per cent. of number of men not less than 25 | 54 | 7 | 9 | 19 | 20 | 9 | 13 | ..... | ..... | ..... | ..... | ..... | ..... |
| Per cent. pay-roll less than 50 per cent. production output. | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Improvement in department | 5 | 10 | 5 | ..... | 10 | ..... | 5 | ..... | ..... | ..... | ..... | ..... | ..... |
| | 161 | 127 | 110 | 115 | 128 | 98 | 115 | 84 | 89 | 81 | 80 | 85 | 82 |
| Pro-rated | | | 64 | | | | | | | | | | |

**Foremen's Bonus Record for 1911**

| | ABG | AC | ADT | AE | AF | AG | AN | BHM | BJP | BLR | BMS | BPM | BKP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Per cent. of total saving | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Per cent. departmental saving divided by number of foremen. | 15 | 9 | 13 | 15 | 15 | 10 | 15 | ..... | ..... | ..... | ..... | ..... | ..... |
| Per cent. monthly salary | 28 | 30 | 25 | 22 | 24 | 25 | 23 | 17 | 27 | 19 | 19 | 21 | 18 |
| Per cent. of number of men not less than 25 | 45 | 7 | 9 | 17 | 18 | 12 | 10 | ..... | ..... | ..... | ..... | ..... | ..... |
| Per cent. pay-roll is less than 50 per cent. total production output. | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Departmental improvement | | 5 | 10 | 5 | 5 | 15 | 5 | ..... | ..... | ..... | ..... | ..... | 5 |
| Totals | 158 | 117 | 123 | 125 | 128 | 128 | 119 | 83 | 93 | 85 | 85 | 87 | 89 |

### Foremen's Bonus Record for 1913

| | ABG | ACG | ADT | AE | AF | AGG | AN | AOG | AP | AQ | AR | AS | AT | AU | AV | AW | AX | AY | BKP | BJ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Per cent. total saving | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 |
| Per cent. departmental saving divided by number of foremen. | 8 | —8 | 8 | 8 | 8 | 4 | 8 | 8 | 8 | 8 | 8 | 8 | —9 | 8 | 8 | 8 | 8 | 8 | ..... | .... |
| Per cent. monthly salary | 30 | 30 | 27 | 26 | 27 | 30 | 27 | 30 | 27 | 27 | 20 | 20 | 20 | 20 | 27 | 20 | 20 | 20 | 20 | 28. |
| Per cent. of number of men not under 25. | 77 | 28 | 6 | 23 | 24 | 66 | 15 | 72 | 17 | 12 | 12 | 12 | 8 | 25 | 15 | 25 | 13 | ... | ..... | ... |
| Per cent. pay-roll is less than 50 per cent. production output. | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| Merit system | 15 | 16 | 26 | 22 | 23 | 8 | 11 | 20 | 22 | 11 | 20 | 9 | 18 | 11 | 22 | 11 | 20 | 20 | 24 | 20 |
| Total | 189 | 125 | 126 | 138 | 141 | 167 | 120 | 189 | 133 | 117 | 119 | 108 | 96 | 123 | 131 | 133 | 120 | 107 | 103 | 107 |
| Pro-rated | | | 31 | | | | 60 | | 77 | 29 | 59 | 54 | 48 | | | | 80 | | | |

| | | | | |
|---|---|---|---|---|
| *BHT* | 96.75 | *IB* | 24.18 | 75 per cent. average |
| *BLR* | 96.75 | *IC* | 8.06 | |
| *BMS* | 96.75 | *ID* | 40.30 | |
| *BPM* | 96.75 | *MM* | 48.37 | |

FIG. 217.—Record of foremen's bonus for three years.

The letters given are not the true initials of the men concerned, the same initials on any sheet represent the same man. Those commencing with *A* are productive foremen; those commencing with *B* non-productive. Those with the last letter *G* are general foremen; those commencing with *I* are inspectors; *MM*, master mechanics, and the letter *T* signifies foreman of toolroom.

The bonuses paid the non-productive foremen are much less than those of the productive foremen. These are: General department, which includes millwrights, sweepers and general repair men; foreman of shipping department; foreman of storeroom; inspectors and master mechanic. They have none of the executive and mechanical responsibilities of the productive foremen.

Another way, shown on the sheet for 1913 bonus, is to pay non-productive foremen and inspectors, a percentage of the average of the bonus paid productive foremen; in this case 75 per cent. This method also gives the non-productive foremen an interest in the bonus earned.

Another advantage of this system is that even if the different factors upon which it is based are posted, it gives no clue to the amount of business done, nor divulges any other confidential information.

**421. Handling automatic machines on the premium plan.** Multiple machine operation offers considerable more difficulty in connection with special systems of compensation than cases where the operator runs but one machine. Especially is this so with automatics where one man may run from one to six machines. The number of machines which one operator has actually in operation varies, not only from day to day but at different times during the same day. Little has been published on the subject of premium plans applied to automatics, possibly the clearest exposition of practical handling of the matter being given in an article by C. B. Lord, general superintendent of the Wagner Electric Co., regarding the methods used in his plant for taking care of the 58 automatics which they operate. (A Coöperative Premium Plan, American Machinist, vol. 41, p. 49.) The following is a condensed review of this article.

The operation of these machines is under two distinct plans:

(*a*) Where a single man operates two or more machines independently of others.

(*b*) Where a number of men operate the same group, such as a number of automatics, and where they are interdependent.

Under the first heading, it is necessary to determine the efficiency of the man with a varying number of machines. From records available at the Wagner plant, this resulted as follows:

| Number of machines | Automatic production | Per cent. of 1 man each capacity | Manual type production |
|---|---|---|---|
| 1 | 100 | 100 | 100 |
| 2 | 200 | 100 | 180 (90 per cent.) |
| 3 | 285 | 95 | ................ |
| 4 | 360 | 90 | ................ |
| 5 | 425 | 85 | ................ |
| 6 | 480 | 80 | ................ |

**Method of Distributing Premium Earned on Automatic Machines**

| | Semi-automatic casting lathe | | | | Automatic bar-stock lathe | |
|---|---|---|---|---|---|---|
| 1 No. of machines in operation | 12 | 12 | 10 | 8 | 9 | 7 |
| 2 No. of men in group including set-up man | 5 | 4 | 4 | 4 | 3 | 3 |
| Hour Rates | | | | | | |
| 3 Operator's rate in cents | 20 | 20 | 20 | 20 | 20 | 20 |
| 4 Set-up man's rate in cents | 34 | 34 | 34 | 34 | 35 | 35 |
| Machine Time | | | | | | |
| 5 Allowance per machine per day in hr. | 15 | 15 | 15 | 15 | 15 | 15 |
| 6 Machine time per day in hr. | 10 | 10 | 10 | 10 | 10 | 10 |
| 7 Premium time per machine per day in hr. | 5 | 5 | 5 | 5 | 5 | 5 |
| Rates and Premium per Machine | | | | | | |
| 8 Operator's rate per hr. in cts. | 20 | 20 | 20 | 20 | 20 | 20 |
| 9 Premium earned per machine in dollars | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 10 Per cent. premium per machine | 25 | 25 | 25 | 25 | 25 | 25 |
| 11 Premium earned per machine amount in cents | 25 | 25 | 25 | 25 | 25 | 25 |
| Group Earnings | | | | | | |
| 12 Total premium per day per group in dollars | 3.00 | 3.00 | 2.50 | 2.00 | 2.25 | 1.75 |
| 13 Total premium per mo. (24 days) per group in dollars | 72.00 | 72.00 | 60.00 | 48.00 | 54.00 | 42.00 |
| Group Earnings Day Rate | | | | | | |
| 14 Operators earnings per mo. 235 hr.–20c. standard day rate | 47.00 | 47.00 | 47.00 | 47.00 | 47.00 | 47.00 |
| 15 | 47.00 | 47.00 | 47.00 | 47.00 | 47.00 | 47.00 |
| 16 | 47.00 | 47.00 | 47.00 | 47.00 | ...... | ...... |
| 17 | 47.00 | ...... | ...... | ...... | ...... | ...... |
| 18 Set-up man 235 hr. total earnings | 79.90 | 79.90 | 79.90 | 79.90 | 79.20 | 79.20 |
| 19 Total earnings per group at day rate | 267.90 | 220.90 | 220.90 | 220.90 | 173.20 | 173.20 |
| 20A. Per cent. of premium earned to each operator. | 17½ | 21 | 21 | 21 | 27 | 27 |
| 21A. Per cent. of premium earned to each set-up man | 30 | 37 | 36 | 37 | 46 | 46 |
| Operators' Earnings | | | | | | |
| 22 Premium to each operator, dollars | 12.60 | 15.12 | 12.60 | 10.03 | 14.58 | 11.34 |
| 23 Day rate earnings, operator, dollars | 47.00 | 47.00 | 47.00 | 47.00 | 47.00 | 47.00 |
| 24 Total earnings, operator, dollars | 59.60 | 62.12 | 59.60 | 57.03 | 61.58 | 58.34 |
| 25 Percentage of premium to day-rate, per operator | 26.8 | 32.1 | 26.8 | 21.3 | 31.00 | 24.5 |
| Set-up Man's Earnings | | | | | | |
| 26. Premium to set-up man, dollars | 21.60 | 26.64 | 27.20 | 17.76 | 24.34 | 19.32 |
| 27 Day-rate earnings, set-up man | 79.90 | 79.90 | 79.90 | 79.90 | 79.20 | 79.20 |
| 28. Total earnings, set-up man | 101.50 | 106.54 | 107.10 | 97.66 | 103.54 | 98.52 |
| 29 Percentage of premiun to day-rate | 27 | 33 | 34 | 22 | 30 | 24 |

A—Based on pro-rating premium earned according to per cent. of each

The relative efficiencies here shown would of course vary with the nature of the work, but it may be assumed that two automatics can be run at 100 per cent. efficiency, since the operations may be timed to make the chucking period come at different times. It would also be probable that no matter what class of work was involved, in running six machines, one would be always shut down, making the efficiency 80 per cent. With some classes of work where the operations were short, this same statement might apply when but three machines were operated.

The premium rules adopted under division (*a*) are as follows: Time allowances are set on the basis of three automatic machines being the same as one non-automatic.

One man operating one or two machines—no premium.

One man operating three machines—20 per cent. of total time saved, after full time has been charged against each machine.

One man operating four machines—16 per cent. of total time saved after full time has been charged against each machine.

One man operating five machines—13 per cent. of total time saved, after full time has been charged against each machine.

One man operating six machines—12 per cent. of total time saved, after full time has been charged against each machine.

The above allowances contemplate machine being set up on daywork time.

The difficulty experienced with this method was due to the varying number of machines a man would operate during the day, and the difficulty of insuring that the time cards corresponded with the actual running time of the machines. (This would seem to offer good opportunity for the installation of electrical machine-operation recorders.)

The scheme followed out under plan (*b*) is different, and avoids these disadvantages. A certain number of machines are assigned to a certain number of operators and a set-up man. The total output of the group is credited to them and the total labor charged against them, including that of the set-up man who shares in the premium. This makes it to his interest to keep the machines going, and even to help the operators occasionally in running the machines.

The premium earned on all Potter and Johnson machines in a group is added together and 25 per cent. of this will be the bonus to be divided. This approximates closely a 50 per cent. bonus with single machine operation. This is divided between the set-up man and the operators in proportion to their hourly rates and time worked. (See group plan.) The set-up man is regarded as the nominal head of each group and is given some latitude as regards the number of operators in the group.

All labor on defective work is deducted from the individual responsible where possible, when not, it is deducted from the group as a whole, no attempt being made to mark each piece distinctively. The hourly rate is guaranteed. The practice in the Wagner shops varies from 7 to 12 machines in a group, and from two operators and one set-up man to four operators and one-set up man. The following tabulation of results indicates how the plan works out.

**422. Bonus figured as an average over period of time.** The bonus system of wage payment being based on the worker attaining a definite degree of efficiency as compared to the standard time which has been set for his work, permits of the bonus being figured to cover the average efficiency shown during a certain period, such as the week or month. This modification is not in the direction of best practice, which is toward making each individual job stand on its own feet, but offers a solution in the case of repair work which is difficult to limit strictly by a standard time. In this case the standard is supposed to represent the average time required; the high jobs during the period will offset the low ones, and give somewhat uniform average results. Procedure of this kind might also apply to jobbing shop practice, where the same job is not repeated frequently, and where of necessity the time allowance or standards cannot be predicted with the accuracy with which they are made in the case of manufactured articles which come through at frequent intervals. *Providing the standards are correct on the average, the stimulation due to a bonus method of payment may be had on this class of work*, and the payment of the bonus for the period instead of for each job prevents the discouragement to the worker which would come from standards set unduly high, or the apparently excessive earnings which would be shown when the standard was set too low.

**423. Premium work for apprentices.** Apprentices are usually started in at a low rate, from 7 to 9 cents per hour, and gradually raised at 6 months or yearly intervals until during their last year the rate is 18 or 20 cents per hour. Some firms have found it good policy when possible, to let the more advanced apprentices have premium work occasionally. The effect is to get them into the habit of moving and thinking quickly, and to accustom them to this method of compensation in which the amount is in proportion to their efforts. The boys are able to earn a little more than their day rate as a rule, and this extra money no matter whether it is spent for tools or for amusement, gives the boy a first impression of premium work which is favorable, and which he is quite likely to keep.

**424. Rates of pay for overtime and nightwork.** The scale varies in different portions of the country. It is usually necessary to pay 25 per cent. higher wages than those prevailing in the neighborhood to hold together a night shift.

Ordinary overtime ranges from time and a quarter to time and a half.

Holidays and Sundays usually call for double time. In some shops the rate of pay increases with the length of overtime. For example, to 9 p.m., time and one-quarter, 9 to 12, time and one-half; after 12 midnight, double time.

**425. Examples of wage calculations, under the different systems.**

**Daywork**

| | |
|---|---|
| Formula for wages = | Example: |
| Hourly rate × No. of hours | Rate 25 cents per hour |
| | Time 4 hours |
| | Wages = 4 × \$0.25 = \$1 |

**Straight piecework**

| | |
|---|---|
| Formula for wages = | Example: |
| Piecework price × number of pieces | Piece price = 25 cents |
| | No. of pieces 4 |
| | Wages = 4 × \$0.25 = \$1 |

**Taylor differential piecework**

Formula for wages

High or low piecework price × number of pieces

Example:

Low rate = 25 cents each

High rate = 27 cents each

Limit for high rate = 12 pieces per day

Output 10 pieces

Wages 10 × \$0.25 = \$2.50

Output 12 pieces

Wages = 12 × \$0.27 = \$3.24

**Group piecework**

Formula for individual wages

$$\frac{\text{Individ. rate} \times \text{hours worked}}{\text{Sum of (individ. rate} \times \text{hours worked) for group}}$$

Example:

Group price = \$18.

| Work-man | Rate, dollars | Hours | Product |
|---|---|---|---|
| *a* | 0.30 | 20 | 6.00 |
| *b* | 0.30 | 18 | 5.40 |
| *c* | 0.22 | 25 | 5.50 |
| | | Total | 16.90 |

Wages to *a* =
$$\frac{6.00}{16.90} \times \$18 = \$6.38$$

Wages to *b* =
$$\frac{5.40}{16.90} \times \$18 = 5.76$$

Wages to *c* =
$$\frac{5.50}{16.90} \times \$18 = 5.86$$

Total \$18.00

**Halsey premium.**

Formula for wages =

[Time taken + $N$(Time limit − time taken) × Rate

Example:

Time limit = 10 hours

Time taken = 8 hours

Hourly rate = 25 cents

$N$ = Premium per cent. = 33.3

$$\text{Wages} = [8 + 0.333(10 - 8)] \times 0.25$$
$$= [8 + (0.333 \times 2)] \times 0.25$$
$$= [8 + 0.660 \times 0.25 = \$2.165]$$

Premium = 16.5 cents

Hourly rate with premium = 27 cents

**Rowan Premium.**

Formula for wages =

$$\left\{\text{Time taken} + \left(\frac{\text{time limit} - \text{time taken}}{\text{time limit}}\right) \times \text{time taken}\right\} \times \text{hourly rate}$$

Example:

Time limit = 10 hours

Time taken = 8 hours

Hourly rate = 25 cents

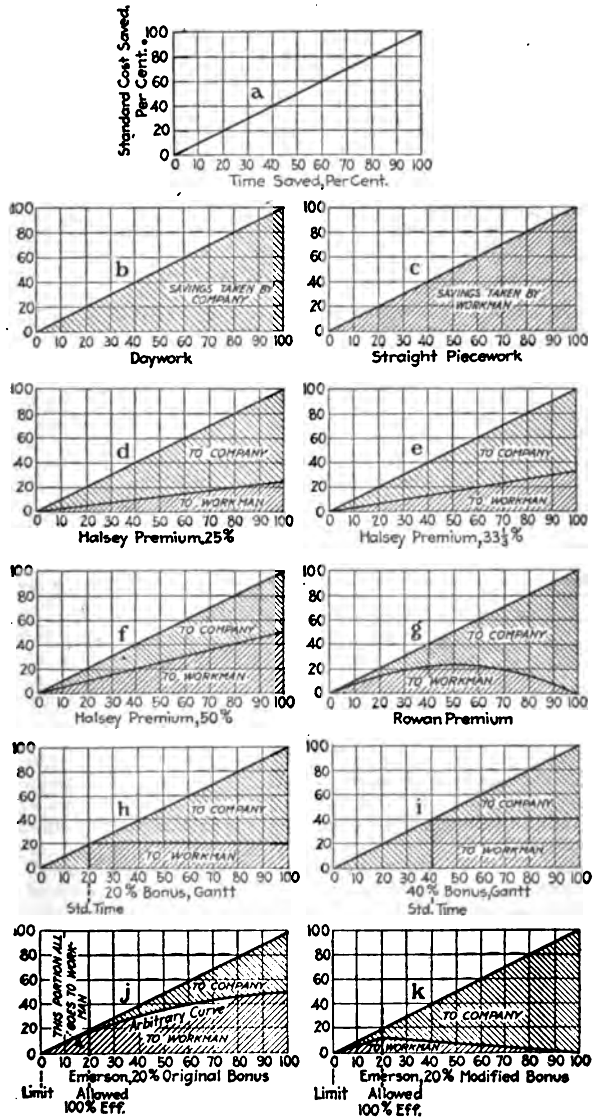
$$\text{Wages} = \left\{8 + \left[\left(\frac{10-8}{10}\right) \times 8\right]\right\} \times 0.25$$

$$\left\{8 + \left[\frac{2}{10} \times 8\right]\right\} \times 0.25$$

$$\{8 + 1.6\} \times 0.25 = 9.6 \times 2.5 = \$2.40$$

Premium = 40 cents

Hourly rate with premium = 30 cents




FIGS. 219–229.—Division of time savings.
How the various compensation plans divide them between employee and

**Gantt bonus system.**

Formula:

When work is completed within standard time,

$$\text{standard time} \times \left(\text{hourly rate} + \frac{\text{hourly rate}}{N}\right) = \text{wages}$$

When work is not completed within standard time

Actual time × day rate = wages

Example:
Standard time = 8 hours
Hourly rate = 25 cents
$N$ = 4 (bonus factor)

Actual performance 7 hours

$$\text{Wages} = 8 \times \left(25 + \frac{25}{4}\right)$$
$$= 8 \times (25 + 6.25)$$
$$= 8 \times 0.3125 = \$2.50$$

Bonus = $0.75

Actual performance = 8½ hours. Hourly rate = 35⁵⁄₁₀ cents.

Wages = 8½ × 25 = $2.12½

**Emerson efficiency system.** (Original plan.)

Formula:

(Standard time × hourly rate) + (standard time × hourly rate × 20 per cent.) = wages

Example:
Standard time = 8 hours
Time taken = 7 hours
Hourly rate = 25 cents
Wages = (8 × 0.25) + (8 × 0.25 × 0.20)
= 2 + 0.40 = 2.40
Bonus = 0.65
Hourly rate with bonus = 34³⁄₁₀ cents

**Emerson efficiency system.** (Modified plan.)

Formula:

(Standard time × hourly rate) + (time taken × hourly rate × 20 per cent.) = wages

Standard time = 8 hours
Time taken = 7 hours
Hourly rate = 25 cents
Wages = (8 × 0.25) + (7 × 0.25 × 0.20)
= 2 + 0.35 = 2.35
Bonus = 60 cents
Hourly rate with bonus = 33⁵⁄₁₀ cents.

## COSTS

**426. Composition of costs.** *Material + labor + factory burden = factory cost.* In which the material is that entering directly into the product and the labor is that performed directly upon the product.

*Factory cost + administrative and selling expense = total cost.* The direct material and labor elements are the only parts of cost that can be definitely known, since burden is applied as an average over-all costs. A total cost therefore is simply a refined estimate.

**427. Uses of costs.** A total cost is for the purpose of establishing a selling price or of finding out how much profit has been made at an already established price. It does not do these things accurately, on account of the necessarily indefinite nature of burden as applied on a percentage basis.

**428. Direct labor costs** are the most useful part of all costs to the plant manager, since through them he can see the way to cost reduction. Direct labor costs may be itemized to any extent desired, along the lines of degrees of timekeeping described in (322).

The degree of itemization which is applied to timekeeping necessarily determines or limits the degree which may be had in the costs.

**429. Material costs** are more or less standard after once obtained, except for changes in design and fluctuations in the material market. Standard material costs may be used over and over again, especially if the various materials such as castings, brass and bronze castings, steel bars, and supplies be grouped in the form of sub-totals, so that they may be corrected as a whole for changing prices.

**430. Where the piecework system** is used, the process of finding costs becomes simply a matter of picking out standards, since both material and labor costs are standard. With all other compensation schemes the labor cost varies as performed.

**431. Cost of orders.** A cost system often has for an object the attainment of the cost of orders by order number, without giving in detail the composition of that cost. This is particularly true with cost systems devised by accountants, since in this form it is comparatively easy to obtain a book balance of costs. Order costs differ with the order system involved, sometimes being the cost of the complete machine and often the cost of parts, according to whether the order system assigns individual orders to parts or not.

*The cost of order system* must be supplemented with detailed performance records for the use of the plant management in controlling costs. These may be the detailed successive operation time records. For the purpose of control these items may be left expressed in time instead of carrying them in dollars and cents. A complete and simple cost-of-order system for the medium size and small plant is described in (482).

**432. Control by comparison.** The following comparisons are useful in helping to control costs. As to total costs: Comparison of costs of the same machine at successive periods. The variation of costs with size in a given design in which there are several sizes. The comparison of the unit costs per pound of machines of a similar type. The comparison of unit costs per dollar of sales. As to unit costs: Comparison of costs on the same part at successive periods. Variation of the costs of similar parts in different sizes of machines. Comparison of costs per pound of various types of parts.

**433. Costs and estimates by unit weights.** By far the most useful all-around comparison is that based on costs per unit of weight. This is either the pound, in machinery manufacturing plants or the hundredweight or ton with the producers of cruder materials. Although the several component parts of a machine vary not a little in their cost per pound, that of the machine as a whole averages up so that the figures obtained are of great value. It is a universal rule, that with any type of machine, as the weight increases, the cost per pound should drop. Thus, a small tool of a given design weighing 10 pounds might cost $1 per pound, not unreasonably, whereas a tool of the same design weighing 1000 pounds would not cost over 10 cents per pound. This law is of great value in making comparisons. If we are comparing machines of the same type, and find that a heavier one costs more per pound than a lighter one, we may be sure that the cost of the heavier one is excessive.

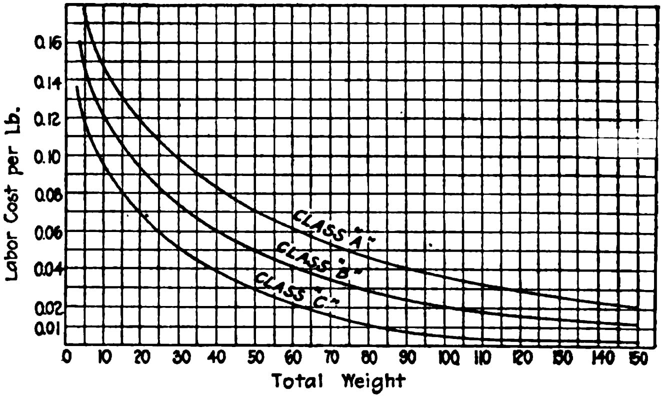
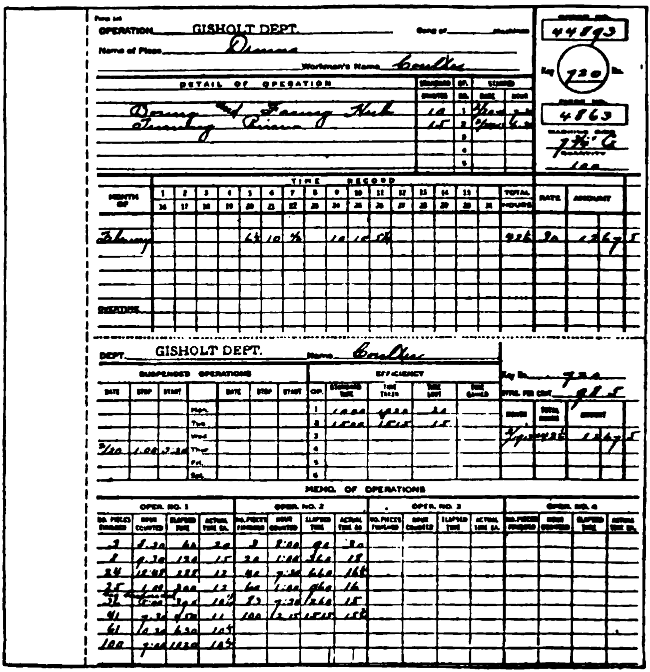



FIG. 230.—Graphical chart of unit weight costs.


OPERATION GISHOLT DEPT.

Name of Piece

Workman's Name

DETAIL OF OPERATION

TIME RECORD

| MONTH OF | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | TOTAL | RATE | AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

OVERTIME

DEPT. GISHOLT DEPT. Name

SUSPENDED OPERATIONS

EFFICIENCY

MEMO. OF OPERATIONS

OPER. NO. 1 OPER. NO. 2 OPER. NO. 3 OPER. NO. 4

FIG. 231.—Perforated time record.

*The unit-weight comparison* is also applied to parts with even more effect. To make full use of this comparison a record should be kept dividing the work into a number of classes and keeping track of the unit-weight cost of each class, both for material and labor. Then when an estimate is required on a new part or machine it is an easy matter to price it accurately after the total weight is estimated.

Fig. 230 illustrates the labor cost per pound variation with several different classes of parts over a various range of weights.

**434. Card records and indexing part and operation costs.** Card index drawers form a most convenient method of arranging and filing part costs, and operation costs. These drawers form a part of a cabinet which contains the complete record of results on stock parts. Fig. 231 shows the form of card which is used for this purpose, as described in the American Machinist, vol. 40, p. 489. It is from the Cleveland Automatic Machine Co., and is perforated so as to divide into two 5 × 8 slips for filing. The upper one constitutes the cost of the individual order, the lower one is a record of the detailed output and the workman's efficiency.

**435. Checking the accuracy of costs.** The majority of plants do not use a balanced system of cost keeping. It is possible, however, to check costs by means of the purchase ledger, pay-roll and inventory, so that the average per cent. of their error may be found. This is effected as shown in the following cost balance report. It necessitates keeping a record of the cost of shipments per dollar of sales and then extending the total cost figures from this. The resulting percentage shows how far the cost per dollar of sales is from being correct.

### Cost Balance Report

January 1, 1913, to January 1, 1914

| Machine No. | Total shipments | Cost per dollar | Total cost |
|---|---|---|---|
| 4*A* ..... | $40,685 | 65.2 cents | $26,526.62 |
| 4*B* ..... | 35,820 | 71.3 cents | 25,439.66 |
| 6*A* ..... | 52,625 | 64.1 cents | 33,722.63 |
| 6*B* ..... | 71,840 | 62.7 cents | 45,043.68 |
| 8*A* ..... | 30,625 | 73.3 cents | 22,448.13 |
| 8*B* ..... | 25,435 | 81.8 cents | 20,805.83 |

| | | | |
|---|---|---|---|
| Total cost of machines shipped. | $173,986.55 | | |
| Cost of repairs and parts shipped | 62,835.41 | | |
| Total cost of shipments.................. | | $236,821.55 | |
| Fixed burden for the year.................. | | 58,125.47 | |
| Total cost of shipments less fixed burden... | | $178,696.49 | |
| Pay-roll total for the year.................. | | $69,138.43 | |
| Purchase ledger total for the year............ | | 100,980.54 | |
| Total recorded annual expenditures......... | | $170,118.97 | |
| Inventory, 1914................ | 73,416.18 | | |
| Inventory, 1913................ | 68,729.35 | | |
| Excess 1914.................. | $4,686.83 | 4,686.83 | |
| Total expenditures corrected for inventory excess.................................. | | $165,432.14 | |
| Cost of shipments, less fixed burden...................... | | | $178,696.49 |
| Expenditures corrected for excess of inventory............. | | | 165,432.14 |
| Error in costs, total.................................. | | | 13,264.35 |
| Error in costs, per cent................................ | | | 7.4 |

**436. Statement of cost reduction.** The form shown in Fig. 232 is useful in recording the results of labor-saving devices and by which a gage of their value may be had. It consists of a comparison of the former cost of performing the operation with the cost which results from using the new appliance. The difference, multiplied by the sales in a given period will show the total saving effected, after deducting the depreciation on first cost and installation charges.

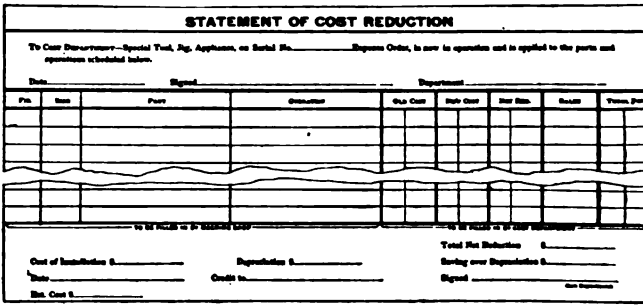

STATEMENT OF COST REDUCTION

FIG. 232.—Statement of cost reduction.

This form may also be used as a convenient means of estimating the value of proposed improvements to see if it will pay to install them.

## BURDEN

**437. Composition of burden.** Broadly speaking, any burden may be said to be composed of three elements:

(*a*) Labor charges.
(*b*) Material charges.
(*c*) Depreciation charges.

The second element in its broad sense is held to represent purchases of all kinds except labor. The third is what might be called the fixed division of burden. It is not subject to control and reduction as a rule, being more or less fixed in nature.

*Manufacturing burden* may be subdivided as follows:

| | | |
|---|---|---|
| Total | Office | Administrative, Selling |
| | Factory | Plant, Department |

*Administrative and selling burden* is something important to know, and to compare from time to time. The common practice is to base it for comparison on the dollar of productive labor, which is the same unit used for comparisons in the factory burden accounts. Oftentimes a manufacturer is surprised to see how much greater this end of the burden is than that chargeable to the operating end.

**438. Factory burden** is divided into plant and department. When there are several producing departments in a plant, the burden varies considerably between them. Therefore burden accounts should be distinct for such departments. The total burden might

remain constant, notwithstanding a rise in that of one department, providing it were balanced by a decrease in others. These fluctuations would not be made evident unless accounts were divided departmentally.

**439. Plant burden** contains the items pertaining to factory expense that cannot be charged departmentally. The comparison of plant burden is made on the basis of the total dollars of productive labor in the entire plant during a certain period of time. That for *department burden* is made on the basis of the dollars of productive labor in the department only.

**440. How burden is applied to costs.** Burden is usually applied to costs as a flat percentage upon the direct labor, either in hours or dollars. It may be subdivided to approximate the true burden more nearly, into department rate, plant rate, and so on. A still closer method of applying it and one that seems more logical is that based on a machine hour rate which takes care of the running cost of the machine as well as the operator's rate.

In figuring the burden or expense rate, the total direct labor is divided into the total amount of the burden for the same period giving the percentage of burden to direct.

**441. Direct labor a fluctuating standard.** While it seems necessary to apply burden upon direct labor, as a percentage, there are disadvantages connected with its use, due to the fact that the capacity of the direct dollar or the direct labor hour varies with the efficiency with which it is used and is therefore a poor measure for efficiency itself. Expense or burden rates do not therefore have any bearing on general efficiency. Neither are they of value for successive comparison of the same item at successive periods, for the same reason. The following examples will demonstrate this fact.

Case 1.
- Time 10 productive hours.
- Total expense, $10.
- Production, 100 pieces.
- Expense rate per productive hour, $1.
- Expense per piece, 10 cents

Case 2.
- Time, 10 productive hours.
- Total expense, $15.
- Production, 200 pieces.
- Expense rate per productive hour $1.50.
- Expense per piece, 7½ cents.

**442. The number of pieces** gives a fixed unit, but cannot be used for comparisons involving more than one kind of piece. The dollar of sales is an almost stationary unit, being changed only with change of selling price, and therefore make a good unit for expense comparisons, since it will include all manner of articles. Other units which are frequently used for special comparisons are the square foot of manufacturing floor space, the unit of weight of the product, the number of individuals employed, and the unit of time.

**443. Detailed analysis of burden. Administrative and selling.**

Administrative.
1. Salaries.
2. Administrative traveling expenses.
3. Postage, telegraph and telephone.
4. Stationery and printing. (Except advertising.)
5. Legal services.

6. Consulting services.
7. Insurance and taxes on office bld'g.
8. Depreciation on office bld'g.
9. Depreciation on office equipment.
10. Other items of administrative expense.

Selling.

1. Salaries.
2. Traveling expenses.
3. Branch office expenses.
4. Catalogs and advertising.
5. Postage, telegraph and telephone relating to sales.
6. Photographic expense.
7. Collection charges.

General.

1. Interest on bonded indebtedness.
2. Corporation, local, branch and government taxes.
3. Interest on investment.
4. Contingent fund.
5. Other items.

**444. Plant expense.** This may be divided into general plant, and heat, light and power. The latter, of its nature, is divisible as a charge against the various departments after its total has been found. General plant items are such as cannot be charged against departments, applying to the plant as a whole. The nature of the items constituting this will, of course, vary with the physical arrangement of the plant, and the nature of the output.

General Plant.

(*a*) Labor Charges.
1. Drafting room.
2. Cost department.
3. Order department.
4. Packers and shippers.
5. Receiving-room employees.
6. Painters.
7. Watchmen and gatemen.
8. To electrician and helpers.
9. For local trucking.
10. To stable employees.
11. To yard laborers.
12. For general supervision.
13. For general unclassified labor.

(*b*) Material charges and purchases.
1. Drafting department.
2. Cost department.
3. Order department.
4. Materials used in shipping. Lumber, nails.
5. Paints, oils, varnish, putty, filler.
6. Electrical supplies for plant used.
7. Hay, straw, feed and stable supplies. Veterinary.
8. Other materials and supplies.
*9. Fire insurance premiums on plant buildings.
*10. Accident and liability insurance.
11. Sanitary supplies.
12. Plant first-aid department expenses.
*13. Factory telephone system.
14. Express and freight prepaid shipments.

(*c*) Depreciation charges.
*1. On drawings.
*2. On costs and estimates.
*3. On pattern loft and equipment.
*4. On drafting, cost- and order-department equipment.
*5. On lunch and wash-room equipment.
*6. On sprinkler system.
*7. On piping underground, sewers, etc.
*8. On fire alarm, hose carts and coils, time clocks.
*9. On other plant equipment.

**445. Heat, light and power.**

(a) Labor charges.
1. Engineers and assistants.
2. Wages to firemen.
3. Wages to laborers and helpers.
4. Labor on department repairs.

(b) Material Charges.
1. Coal.
2. Oils and grease.
3. Materials used in repairs.
4. Electrical supplies.
*5. Boiler and flywheel insurance premiums.
6. Other materials.

(c) Depreciation charges.
*1. On buildings.
*2. On heating equipment.
*3. On engines.
*4. On boilers.
*5. On electrical machinery.
*6. On power wiring and lighting system.
*7. On minor equipment.

From the above accounts in addition to the comparison of expense per dollar of productive labor for power, the actual cost per horse power can be easily computed, providing means are at hand to measure the output. Another useful comparison is that of the number of pounds of water evaporated per pound of coal. This gives the management a line on the efficiency of the boilers, and how well the firing is being done. All that is necessary to secure this is a measure of the feed water during the comparison period, and to secure this there are a number of devices which make a continuous record of the feed water used.

**446. Departmental expense.** While this varies with the nature of the department concerned, it is easily outlined for any department by adhering to the definition of burden expense, and to the three elements composing it, namely, labor charges, material charges and depreciation charges. As a guide to the composition of department burden accounts, three departments are herewith shown, comprising foundry, blacksmith and machine.

**447. Foundry department burden.**

(a) Labor charges.
1. Molders and coremakers for non-productive work.
2. Pattern transportation.
3. Flask transportation.
4. Casting transportation.
5. Cupola tenders.
6. Crane men.
7. Foundry laborers.
8. Casting cleaners.
9. Sand blasters.
10. Flask carpenter.
11. Foundry machinists.
12. Weighmaster and clerks.
13. Supervision.
14. Defective work.

(b) Material charges.
1. Molding sand.
2. Facing, graphite, charcoal, seacoal.
3. Small tools, rammers, shovels, riddles, brushes.
4. Flask lumber, nails.
5. Chaplets, rods and miscellaneous.
6. Core sand.

7. Core oil, molasses, flour.
8. Material loss through re-melt of defectives. (Of importance only on the more expensive materials such as brass, aluminum.)

(c) Depreciation charges.
*1. On buildings.
*2. On cupolas and melting furnaces.
*3. On traveling cranes.
*4. On molding machines.
*5. On minor equipment, core ovens, blowers, racks, elevators, pumps, air pipe, etc.
*6. On metal flasks. (Wooden flasks considered as adding nothing to the value of the plant, being a current expense, and cared for through (a-10) and (b-4).)

(d) Proportion of the light, heat and power charges due this department.

**448. Machine department.** In a great many plants, the tool room and the stock room contribute the greater part of their efforts toward the welfare of the machine department, and may therefore logically be included as a part of its burden. Other cases, where they serve four or five departments equally, would require a separate division for them.

**449. Machine department burden.**

(a) Labor charges.
1. Machinist engaged in non-productive work.
2. Tool makers on new tools.
3. Tool repairs.
4. Machine repair.
5. Installation of new machines.
6. Machine-shop helpers and laborers.
7. Tool-room helpers and laborers.
8. Stockkeeper and assistants.
9. Truckers and wheelers.
10. Clerks.
11. Tool tender and tool boys.
12. Repairs to department, other than the machines.
13. Defective or spoiled work.
14. Supervision.

(b) Material charges.
1. Belting.
2. Lubricating oils and greases.
3. Lard oil and cutting compound.
4. Waste and wiping rags.
5. Small tools, reamers, drills.
6. Hand tools, chisels, files.
7. Materials entering new tools.
8. Materials used in tool repair.
9. Materials used in machine repairs.
10. Materials used in department repairs, other than machine equipment.
11. Material loss due to spoiled and defective work.

(c) Depreciation charges.
*1. On buildings.
*2. On overhead equipment, pulleys, line shaft, hangers.
*3. On machines and foundations.
*4. On traveling cranes.
*5. On electrical equipment.
*6. On other equipment.

(d) Proportion of light, heat and power charges due this department.

**450. Blacksmith department burden.**

(a) Labor charges.
1. Smiths and helpers for non-productive work.
2. Tool dresser.
3. Laborers.
4. Repairs to the department.
5. Supervision.
6. Spoiled work.

(*b*) Material charges.
1. Coal and coke.
2. Tempering and hardening compounds, lime.
3. Small tools.
4. Materials used in department repairs.
5. Material loss on spoiled work.

(*c*) Depreciation charges.
1. On building.
2. On equipment, forges, blowers, furnaces, piping, tanks, anvils.

(*d*) Proportion of the light heat and power charges due this department.

**451. Handling burden or expense accounts.** Burden may be divided into two parts, the variable and the fixed. Variable burden is that which comprises labor other than productive, and materials regularly consumed in plant operation outside of the direct materials going into the product. The fixed burden consists of the items such as depreciation, interest on investment, taxes, insurance. These items being of their nature not usually permissible of reduction may be dismissed from the present discussion.

In dealing with the variable items of burden, the first step is to classify them carefully into accounts, so that the charges will always be comparative. In other words, it will not do to keep changing items from one account to another and expect to get results of any value.

**452. The main subdivision** of the variable burden accounts is between material and labor. Each of these should be further subdivided into units of convenient size for comparison. In many plants subdivisions are further made between departments. It is understood that each group is summarized for a definite time period. An illustration of a condensed comparative burden report is shown below.

**Comparison of Burden Accounts**

| | June 1 to 8 | | June 9 to 16 | | June 17 to 24 | |
|---|---|---|---|---|---|---|
| Total production...... | $3540.28 | | $3618.40 | | $3420.42 | |
| Account | Total | Per dollar productive | Total | Per dollar productive | Total | Per dollar productive |
| 1. Supervision, foremen and Asst's..... | $972.40 | 27.4 | $975.28 | 27.0 | $970.15 | 28.5 |
| 2. General labor and helpers........... | 707.28 | 20.0 | 865.32 | 23.9 | 690.15 | 20.2 |
| 3. Labor on defective and spoiled work.... | 40.16 | 1.1 | 30.28 | 0.8 | 35.60 | 1.0 |
| 4. Teamsters and shipping............... | 350.18 | 9.8 | 368.39 | 10.2 | 420.18 | 12.3 |
| 5. Labor in heat, light and power dep't.... | 248.60 | 7.0 | 275.20 | 7.6 | 268.10 | 7.8 |
| 6. Etc............. | ........ | ...... | ........ | ...... | ........ | ...... |
| 10. Waste, oils kerosene, etc.............. | 92.14 | 2.6 | 85.14 | 2.3 | 83.24 | 2.4 |
| 11. Files, emery cloth, chisels, hand tools.. | 120.38 | 3.4 | 110.18 | 3.0 | 118.19 | 3.4 |
| 12. Reamers, drills and small tools......... | 140.67 | 3.9 | 125.60 | 3.5 | 157.10 | 4.6 |
| 13. Etc.............. | ........ | ...... | ........ | ...... | ........ | ...... |

**453. Items of expense** should be figured in groups against the dollar of productive pay-roll or the dollar of output value in the

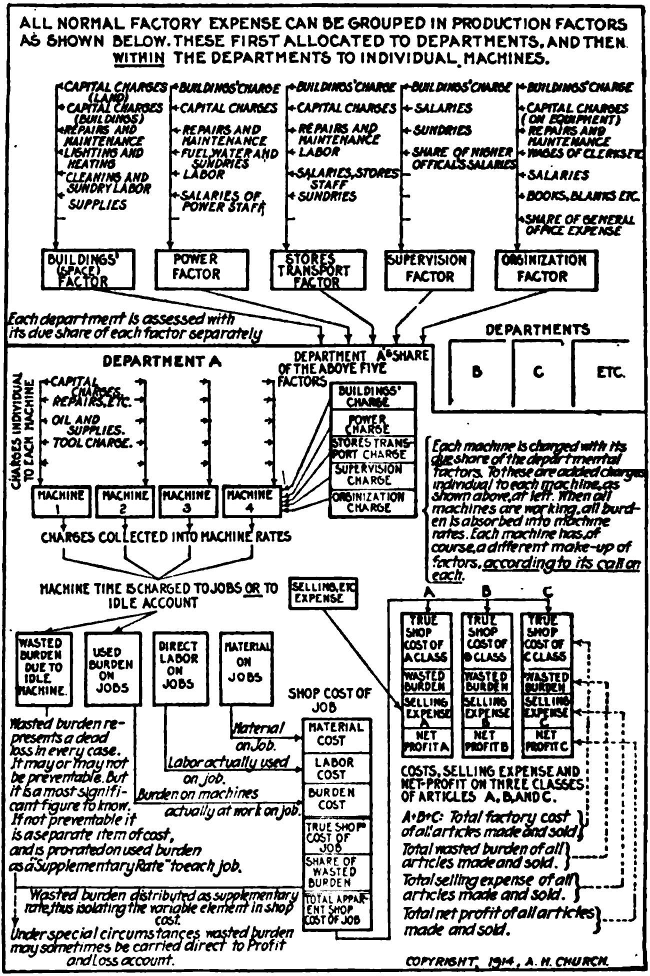



FIG. 233.—Analysis of expense with production factors, by A. Hamilton Church.

department concerned. A unit expense rate for each account is thus obtained which must be watched to prevent increase, and

studied to effect reduction. The use of oils, waste and other materials in this group, for example, must not be allowed to exceed so many cents per dollar of productive labor.

**454. Degree of itemization of burden accounts.** In considering just how far to carry this analysis, it will happen that a manager is undecided whether to lump certain items, or split them into further detail. As a help in making the decision a useful question to ask is, "Is the amount of money involved in the item small enough so that I do not need to know just where it goes?" If the answer is "No," the item should be still further split. For when you lump two or three elements together, each calling for a conclusion, the general idea becomes obscured, just as vision is indistinct when we try to see two things at once. It would save time no doubt, in a certain sense, if we had but one bin in a stock room, so that we could dump into it haphazard everything which was received, but it would not help matters when you wanted to find an article. The more bins that we provide to contain the various items of manufacturing expense, the easier it will be to pick out the information which will point to their control.

Take, as an example, expense records covering the operation of a machine shop. The total would be expressed as follows:

Total expenses for 1913, $125,627.45.

While this statement may mean a whole lot, especially when compared to the shipment value made during this period, it does not tell very much. A second step toward a broad analysis would be:

| | |
|---|---|
| Direct materials | $35,608.23 |
| Indirect materials | 10,212.11 |
| Direct labor | 27,549.16 |
| Indirect labor | 36,758.22 |
| Depreciation and fixed charges | 15,499.73 |
| Total | $125,627.45 |

This is a step in the right direction but not far enough. To illustrate the further analysis without spending too much time at it, let us forget direct materials and direct labor, and depreciation and fixed charges, and see how we can deal with indirect labor and materials.

Indirect labor for year 1913, $36,758.22.

| | |
|---|---|
| 1. Supervision | $6,250.14 |
| 2. Clerical | 1,425.00 |
| 3. Non-productive work of machinists | 2,364.00 |
| 4. Tool makers | 15,121.32 |
| 5. Tool and shop repair | 5,161.84 |
| 6. Machine installation labor | 741.16 |
| 7. Helpers and laborers | 4,191.20 |
| 8. Stock room and tool crib | 1,503.56 |
| Total | $36,758.22 |

Indirect materials for year 1913, $10,212.11.

| | |
|---|---|
| 1. Belting | $1,185.20 |
| 2. Lubricating materials | 1,416.18 |
| 3. Cutting oils and compounds | 810.25 |
| 4. Waste and wiping rags, etc. | 750.15 |
| 5. Small tools and supplies | 2,597.75 |
| 6. Tool steels | 1,684.16 |
| 7. Repair material | 1,318.17 |
| 8. Spoiled and defective | 450.25 |
| Total | $10,212.11 |

We have, as it were, put our expense items under a microscope of eight times the magnifying power of that used in the second step. This is not yet powerful enough, for although we can distinguish the various members of the body we cannot see their structure. Let us take element No. 4 of the indirect labor account, namely, "Tool Makers," and put it under closer scrutiny.

This next step should be in the direction of answering the question, "What did they do?" In other words, what did we get for our money?

Tool makers, labor for 1913, $15,121.32.

| | |
|---|---|
| (a) Standard tools | $2,798.91 |
| (b) Special tools | 4,779.87 |
| (c) Jigs | 4,183.29 |
| (d) Gages | 563.20 |
| (e) Repairs to small tools | 860.17 |
| (f) Repairs to machine tools | 1,540.63 |
| (g) Experimental work | 385.25 |
| Total | $15,121.32 |

And still we have not reached a point fine enough in our analysis. Take item (a) for instance, standard tools. The question of what kind and how many were produced for the given amount is quite an important one, since we might find, as many shops do, that we could have bought these tools at a price less than our cost. Regarding the special tools and jigs, in items (b) and (c), we are interested to know something about their performance after being put into use; whether they made sufficient savings to pay for the money that we invested in them. We would also like to know whether the design of these tools and jigs was such that they could be built for a minimum cost, considering the effect they were intended to produce. What we are after now are points of attack, and questions of this nature help us to locate these points on the map of our proposed expense reduction campaign.

**455. The same procedure** applies to the treatment of the indirect materials accounts. Take item No. 4, waste and wiping rags. We spent $750.15 for this in 1913. Was it too much, or too little? If the machines are being kept clean, it is evidently not too little, although the reverse is not true, that if they are not clean it is not evidence that the amount is not enough, for it may not be used properly. But granting that the machines are in good condition as far as cleanliness is concerned, evidencing that the total is sufficient, how are we to know if this item may be reduced? The following questions help to throw light on this point:

What was our average consumption in pounds per man per week? How does this compare with friend Jones' factory where the same kind of machines appear to be kept in clean condition? Are there restrictions as to its issue in accordance with the needs of the various machines, or is it given out so much per man, irrespective of whether he runs a screw machine or an emery wheel? Is it issued by the bundle, made up according to the reach and judgment of the stock-room boy, or is it weighed to secure uniformity? A manager cannot put these mental questions to himself and furnish the answers without obtaining convictions as to the possibilities and means toward expense economies.

## SOURCES OF COST INFORMATION

**456. Sources of cost information.** The cost of castings per pound.

*When purchased.* Obtained from the purchase ledger entry. A list of standard costs per pound kept revised and up-to-date for use of cost department in this respect.

*When made.* Obtained as an average cost per pound by dividing the cost of operating during a given period including the fixed charges for this period by the total production of good castings during this period. Sometimes obtained as detailed costs by keeping separate time on molding and core-making on order numbers and to this adding a percentage representing other charges and also the cost of the melted metal in the casting.

**457. The parts that are used on a given order.** Obtained either from the bill of material, or from the stock and stores orders when a complete material delivery system is in vogue.

**458. The weight of a given part.** *Castings.* Obtained from the pattern record card, which usually contains this information, or from the foundry production-report by order number. Sometimes where methods are not installed which cover this point the cost office must secure the weights through its own efforts or by special request to the foreman of the department concerned.

**459. Forgings.** The weight of forgings purchased is secured from the invoice since these are charged by the pound. On those made at the plant, the rough weight of the stock used is reported by the foreman usually upon the order for the forging. The finished weight is secured through the efforts of the cost office. Both rough and finished weights of forgings and castings are made a matter of record.

**460. Bar and screw stock.** The weight of parts made from this material are obtained often by calculation, using tables of weight of round or hexagonal stock. The finished weight is obtained by actual weighing, through the efforts of the cost office. Where bars are charged as used against order numbers, it is a simple matter to divide the total weight reported by the number of pieces.

**461. The allowance for chips.** Obtained by taking the difference between the rough and finished weight of the part and multiplying it by the market price of turnings or borings, correcting the amount so obtained by a percentage of 10 per cent. to 20 per cent. for loss.

**462. The price of nuts, bolts, studs and other fittings and supplies.** Originally obtained from the purchase ledger which is indexed by commodity. Generally these data are kept in the form of price schedules, or hardware lists, for ready reference in the cost department, the discounts being given and kept up-to-date by notification of changes by the purchase clerk.

**463. The prices of special purchased parts, motors.** Obtained from invoice filed according to order number, or from price memoranda sent to cost department by purchase clerk upon receipt of goods and billing.

## *Products of a Cost Department*

**464. Analysis of manufacturing expense.** A weekly or monthly report classifying by accounts both material and labor items direct and indirect. Fixed charges omitted. The ratio of the various items to total productive labor or to the total value of shipments for the given period is often shown, as well as the corresponding average for the preceding period and for the preceding year.

**465. Costs of plant orders.** A weekly or monthly report compiled by order number, showing the labor and material which has been expended during this period on the various plant orders. This takes care of extensions and repairs to buildings and equipment, costs of tools, jigs and fixtures.

**466. Cost of production orders.** A weekly or monthly report by production-order number, showing the labor and material which has been expended during the given period on the various production orders. Sometimes this is extended to include the total material and labor on the order if any work has preceded the period. No detail is given on this report which consists merely of order numbers and totals for material and labor to correspond. A report of this kind is of course possible only in connection with a complete "cost-of-orders" system.

**467. Department report.** A weekly or monthly report of the total direct and indirect labor in each department, number of men working and total hours worked, number of lates and absences, amount of premium or bonus earned, and sometimes the efficiency of the department as a whole.

**468. Efficiency report** (individual). A weekly or monthly report showing the efficiency of each productive workman as indicated by the ratio of actual time taken to standard time. This report is possible only where standard time allowances are made and of value only when these are accurate as the result of time study.

**469. Report of defects and errors.** A weekly or monthly report showing the number, nature and cost of the various errors and defects and to what department they are to be charged. This report is usually arranged according to departments debited. Sometimes broken promised dates are considered as errors and also reported, although they cannot be priced as a rule unless the order in question is under penalty.

**470. Cost of power plant operation.** A weekly or monthly report showing the total power consumption and total cost operation, cost per unit of power, and so on. Compiled from the engineer's daily report, see (121).

**471. Card summary of total cost.** A small card form containing no detail as to the cost of various parts, but giving totals under the heads of castings, forgings, purchased parts, total material, direct labor, burden, total cost, weight, and cost per pound; is filed by name, type and size of machine and may be used in addition as a key card to show the location of the detailed cost.

[illegible] **Detailed cost.** Consisting of itemized and priced bills of [illegible] and labor sheets covering each part. The assembling. [illegible] testing are also included.

**473. Part costs** consist of records commonly in card form on which successive labor costs are recorded, the average of which is used as the labor on the part in making the detailed cost sheet.

**474. How various items are brought into costs.** *Patterns* are sometimes considered a part of direct cost, particularly in cases where the run of work is along special lines and the patterns cannot be depended upon to be of service more than once. Where they are used many times, patterns are carried as part of the burden. Sometimes both schemes are in effect in the same plant to cover different classes of work. There is no confusion entailed as long as the same item is not charged in two places.

1. INDIVIDUAL PATTERN COSTS:

*Materials.* Pattern lumber: Reported in board feet by the pattern foreman, usually upon the pattern order. Castings: Reported by the pattern foreman as above, giving weights, or obtained from the foundry production report by order number. Miscellaneous: screws, nails, brads, glue, dowells, shellac, pattern letters. Figured as a percentage in connection with the department burden.[1] Sometimes applied to the pattern cost on the basis of so much board foot, determined by experience.

[1] Where individual pattern costs are obtained, a pattern department burden is figured and added to them. Where patterns are figured as an item of expense the whole expenditures for this department form part of the general burden. This gives rise to confusion in cases where both methods are in use at the same time. In cases of this kind the department burden should be figured and added as a percentage to the individual pattern costs called for, but the amount of the burden so added should be deducted from the general burden as otherwise it will be charged twice.

*Labor.* Pattern makers: Reported on time cards charged to order number or against pattern number where the order system is not used. Supervision and general help: Charged directly into the department burden from the pay-roll distribution, or from the standing order reports. Fixed charges, depreciation: Apportioned to the department and added to the department burden.

2. PATTERNS FIGURED AS AN ITEM OF EXPENSE:

*Materials.* All materials used charged directly into the general burden account. Sometimes itemized as new patterns, repairs and changes. Amounts and kinds used obtained from record of purchases most conveniently, but sometimes reported in daily or weekly material consumption reports, as used.

*Labor.* All labor charged directly into the general burden account. No time cards necessary for cost purposes except as to new patterns, repairs and changes. All labor often charged directly into general burden account from the pay-roll distribution.

Fixed charges, depreciation, etc., charged directly into the same account as above.

**475. Tool costs.** Tools, like patterns, are sometimes charged as part of the individual costs in which case they are considered as direct. As a rule, they are treated as part of the general burden. New tools and jigs are treated as if they were purchased equipment and depreciation is allowed on their cost price varying from 20 to 100 per cent. Tool repairs and small tool manufacture or purchase are considered as current expense and enter directly into the burden in their total form. So also does the tool steel which is used for cutting. While an itemized cost of new tools is desirable for purpose of control it is not necessary for accounting purposes. If material and labor on new tools are kept in separate accounts, the department burden can be applied as a percentage of the total, and depreciation figured as a flat rate on the resulting figures. As in the case of patterns care must be taken that items are not charged

twice, the subject of a burden upon burden being rather complicated. The following analysis of general burden due to tool department may make this clear:

*General burden due to tool department.* (*a*) A percentage (determined by depreciation) of the cost of tools, jig and fixtures falling in the class of "extensions," this cost being composed of direct labor, direct material and a percentage burden representing indirect labor and materials and department fixed charges:

*Plus:* (*b*) All tool-room charges, both direct and indirect, and including fixed charges.

*Minus:* (*c*) The cost (including department burden) of the "Extensions." (The distinction between (*a*) and (*c*) should be noted. The former is a percentage of the latter and therefore amounts to less.)

## Tool Department

*Materials used in extension.* Sometimes reported upon the tool production orders where individual tool costs are kept. Where these are not kept, the materials used in new tools may form a standing order and be reported under this number as regards castings, parts from store, and purchases.

*Other materials used in tool room* are reported either as purchased, from purchase records; as requisitioned from stores, by means of stores orders; as consumed; where the tool department is provided with sub-stores and materials are issued on tickets.

*Labor on tool extensions.* Reported on daily or order time cards charged to the given production order number, or where this system is not used, to the tool or jig number. Where individual costs are not kept, the labor on extensions in this department may be charged from a standing order number.

*Other labor in the tool department.* Labors on repairs, on small tools of regular consumption, helpers, tool crib tenders, tool boys, are charged directly into tool expense and form an item of factory expense.

*Fixed charges and depreciations.* The items of this nature relating to this department are charged directly into factory burden, after being corrected for that portion of them entering into extension costs.

**476. Shipping, boxing and crating.** Where individual costs are required in connection with the general handling of this subject as a burden item, the same complications are offered as under pattern and tool handling. To avoid this, all of the expenses arising from shipping and crating are considered as a part of factory burden. Any charges made to customers for this service may then be considered as additions to profit.

*Materials; Labor.* If collected on individual orders shipped, for purposes of cost control, the shipping bill may be utilized to collect this information and transmitted to the cost department. Otherwise, total labor is derived from standing order numbers upon the pay-roll distribution. This may be divided into as many headings as required, such as domestic and export shipping, or according to a class of machines. In this case materials are usually charged directly into burden as purchased.

*Fixed charges, and depreciation* form a part of general factory burden.

**477. Heat, light and power.** These items form a part of the general factory burden, but are distributed differently in different plants. Where the power consumption in the various departments is uniform, it may be applied directly to the general burden account and thus applied on direct labor as a percentage. Where there is considerable variation in the relative consumption between departments, per employee, the total cost of heat, light and power may be apportioned between departments in proportion to the average power consumption of each compared with the total, and carried as a part of the departmental burden.

*[illegible]ials.* Coal is the most expensive commodity used in this connec- [illegible]to-date power plants measure the coal used, reporting it as con- [illegible]wever, since the great bulk of coal prevents much excess storage

capacity in the average plant, not much error is caused by charging it off as purchased.

*Other supplies, oils, grease, etc.* Reported either as purchased from purchased records, as requisitioned into the power plant from stores, or as consumed.

*Labor.* Reported either on daily time cards or taken from pay-roll distribution or standing order reports.

*Depreciation* forms a part of the total cost, however divided.

**478. Figuring costs over a period of time.** An accurate method of figuring labor costs in the case of departments producing the same work over long periods, is to divide the labor for a period of several months or more by the output during the same time. This process may be made continuous, since there is hardly any labor involved.

**479. Fixed charges.** Certain elements of burden cannot be directly charged into the expense of manufacturing in a given year and so are distributed over the number of years which are figured to be the probable life or useful life of the purchase or expenditure. Such items include land, buildings, equipment, extensions to buildings and equipment, and the like. Among the fixed charges are also commonly included insurance premiums, interest on bonded indebtedness, sinking fund, although unlike the former items these can be definitely defined for each year. In fact the term—fixed charge—is made to include almost all inevitable and generally constant items of expense as distinguished from supplies, which also form a portion of burden, but which are capable of control and fluctuate more or less.

**480. Relation of standing orders to costs.** The iron-clad rule in connection with many cost systems is "no work done without an order, and no order without a number." All labor is charged against order numbers as is also all material, both direct and indirect. The compilation of costs as well as that of classified burden accounts is therefore a process of obtaining the costs of orders. As a compromise to save clerical work in entering orders to cover the labor of those who do the same work day after day, as shop sweepers, yard men, inspectors, standing orders are issued to cover these actions and each is provided with a number known as the "Standing Order Number." All work done of this kind is reported on the standing order number concerned and is distributed on the pay-roll and material ledger in the same manner.

**481. A balanced cost system for the small plant.** In a paper presented before the National Association of Machine Tool Builders, B. A. Franklin describes a simple system of obtaining balanced costs in a factory employing 150 men. The clerical force taking care of it comprises the bookkeeper and his assistant who do this work in addition to their regular duties. Where detailed or operation costs are not thought necessary, a system of this kind should give satisfaction and may be applied in much smaller plants than the one described.

**482. A proved cost.** This system was built on certain definite principles: *The first was* that to get the cost of machines, the practical way was to get the cost of the whole and all machines and develop the part or detail cost as desired or necessary; not to get all the detail costs and throw them together to get the whole cost.

*The second principle* adopted was that the costs should be obtained in such a manner as to be provable as correct. This involves getting the cost of everything done in the factory.

*Divisions of cost.* The costs are gathered along four main divisions:

(*a*) *Material.* That which becomes a part of the finished machine. All other material is classed as expense.

(*b*) *Productive labor.* That part of the pay-roll which pays for work actually spent in shaping the machine to its finished condition.

(*c*) *Factory expense.* That money leaving no permanent asset in advancing the career of productive labor in shaping material into the finished product.

(*d*) *Selling expense.* All money spent in disposing of the production to buyers, reducing the gross sale price to a net income to the factory. This expense is shown in a per cent. relation to gross sales.

At the start all moneys spent were divided into classes just as costs were to be divided, namely, material, productive labor, factory expense and selling.

We therefore introduced a form of journal called the *voucher register.*

Fig. 234 illustrates this, and the entries made tell their own story. Every cent expended in the business for any purpose whatsoever goes through this book, so that we know that nothing is missing. The miscellaneous column at the far right is for certain money spent which cannot be considered as immediately chargeable into the four elements named, such as permanent assets, additions to the plant, machinery, and the like, or exchange accounts, as note payments, and so on.

*The pay-roll is divided* into productive and non-productive labor, and the non-productive labor is put under the head of factory expense.

After the productive labor comes expense. All items whatsoever of expense are placed in this column; and in the final column, called account, is placed the name of the expense. Once a month, as will be seen, the footing of these columns prove with the total of money spent, and one posting a month gives all the information it is designed to gather on these points.

Once a month this expense is analyzed and shown on Fig. 235, expense analysis.

*In the matter of non-productive labor*, every labor item that could not be fairly and justly distributed against an order number was called non-productive, and put into expense, and thus equally divided over all orders. This non-productive labor was shown in considerable subdivision.

It will be noted that there are for each month two columns in the expense analysis. One column represents the actual expenditure; the other represents the amount chargeable to the particular month. For example, taxes and insurance are paid generally once a year; to get a fair monthly per cent., they are pro-rated one-twelth to each month in the year. Supplies may be bought in such quantity as will last several months. When they are reported as used, the used amount can be set down as a charge against the month in which

| Date invoice | Voucher No. | Name | Item | Date paid | Material: Amount | Material: Iron castings | Material: Iron and steel | Material: Lumber | Material: Brass castings | Material: Sundry material | Product. labor | Expense | Miscellaneous | Account |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 00 | | | | | | | | | | | | | |
| 5/10/07 | 01 | Pay-roll | | 5/10/07 | 2502.72 | | | | | | 2016.09 | 484.63 | | N. P. Labor |
| 4/10/07 | 02 | Johnson Fdry. Co. | Iron Castings | 5/10/07 | 304.17 | 304.17 | | | | | | | | |
| 4/28/07 | 03 | Smith Brass Co. | Brass Castings | 5/10/07 | 208.29 | | | | 208.29 | | | | | |
| 4/28/07 | 04 | Kilby Lumber Co. | Spruce | 5/10/07 | 2300.00 | | | 2300.00 | | | | | | |
| 4/18/07 | 05 | Jones Tool Steel Co. | | 5/11/07 | 1800.25 | | 500.03 | | | | | 1300.25 | | Tool Steel |
| 4/18/07 | 06 | Jackson Supply Co. | Files | 5/11/07 | 18.00 | | | | | | | 18.00 | | Files |
| 4/29/07 | 07 | Wilmot Screw Co. | Screws | 5/11/07 | 25.00 | | | | | 25.00 | | | | |
| 4/29/07 | 08 | Samson Machine Co. | Planer | 5/11/07 | 2000.00 | | | | | | | | 2000.00 | New Machinery |
| | 09 Etc. to 49 | Etc. | | | | | | | Etc. | | | | | |
| Total | | | | | 14872.16 | 304.17 | 1000.23 | 2300.00 | 208.29 | 500.00 | 4020.18 | 4539.29 | 2000.00 | |

FIG. 234.—Voucher Register.

| Items | Inventory expense supplies | January, 1907 | | February, 1907 | | Etc. |
|---|---|---|---|---|---|---|
| | | Actual | Used | Actual | Used | |
| GENERAL EXPENSE | | | | | | |
| Office | | | | | | |
| Executive | | | | | | |
| Cost and Bookkeeping | | | | | | |
| Other Clerical | | | | | | |
| Stationery | | | | | | |
| Postage | | | | | | |
| Telephone | | | | | | |
| Telegraph | | | | | | |
| Legal | | | | | | |
| Sundries | | | | | | |
| Total | | | | | | |
| Drafting Room | | | | | | |
| Draftsmen | | | | | | |
| Supplies | | | | | | |
| Total | | | | | | |
| Factory | | | | | | |
| Executive | | | | | | |
| Clerical | | | | | | |
| Storeroom | | | | | | |
| Cleaning Up | | | | | | |
| General Labor | | | | | | |
| Inward Cartage and Freight | | | | | | |
| Inward Express | | | | | | |
| Total | | | | | | |
| Shipping | | | | | | |
| Labor | | | | | | |
| Lumber | | | | | | |
| Supplies | | | | | | |
| Total | | | | | | |
| Tool Room | | | | | | |
| Files | | | | | | |
| Drills | | | | | | |
| Hack Saws | | | | | | |
| Emery Wheels | | | | | | |
| Taps | | | | | | |
| Cutters | | | | | | |
| Reamers | | | | | | |
| Tool Steel | | | | | | |
| Labor Sharpening Tools | | | | | | |
| Labor Making Tools | | | | | | |
| Total | | | | | | |
| Supplies | | | | | | |
| Oils | | | | | | |
| Electric Lamps | | | | | | |
| Sundry Supplies | | | | | | |
| Total | | | | | | |
| Grand Total General Expense | | | 4000.00 | | 3444.00 | |
| Monthly Productive Labor | | | 8000.00 | | 8200.00 | |
| % Expense to Productive Labor | | | 50% | | 42% | |
| Average % Expense to Productive Labor | | | | | 45.8% | |
| Amount to Department 1 | In proportion to productive labor of | | 2000.00 | | 2500.00 | |
| Amount to Department 2 | | | 1000.00 | | 1250.00 | |
| Amount to Department 3 | | | 1000.00 | | 1250.00 | |

| Items | Inventory expense supplies | January, 1907 | | February, 1907 | | Etc. |
|---|---|---|---|---|---|---|
| | | Actual | Used | Actual | Used | |
| POWER | | | | | | |
| Labor | | | | | | |
| Coal | | | | | | |
| Water | | | | | | |
| Oils | | | | | | |
| Sundry Supplies | | | | | | |
| Total Power Cost | | | 300.00 | | 325.00 | |
| Share to Department 1 | Divided | in pro- | 50.00 | | 54.16 | |
| Share to Department 2 | portion t | o use | 150.00 | | 162.50 | |
| Share to Department 3 | | | 100.00 | | 108.34 | |
| Depreciation | | | | | | |
| Taxes | | | | | | |
| Insurance | | | | | | |
| Total | | | | | | |
| Share to Department 1 Div | ided in p | ropor- | 300.00 | | 300.00 | |
| Share to Department 2 tion | to value | of in- | 400.00 | | 400.00 | |
| Share to Department 3 ves | tment in d | epart- | 300.00 | | 300.00 | |
| | ment | | | | | |

FIG. 235.—Expense Analysis.

they are used. A little thought will show that this method permits a dollars and cents perpetual inventory if the amount on hand at the beginning is set down.

*Productive labor.* The pay-roll by means of Fig. 236 forms a means of gathering and providing the productive-labor costs.

This method may seem complicated where there are many orders. In this plant, where there was an average of 100 different orders per week in each department, it proved simple and economical.

*Material used.* A record of the use of material is obtained by means of Fig. 237. This material is gathered through storeroom and foreman's reports.

This offers us a ready means to check the use of material, since beginning with an inventory of raw material and adding constantly the purchases and deducting the use, we have a figure showing what material should be on hand. An actual inventory shows the degree of accuracy and error.

Fig. 238 shows how all this information is gathered together into the final accounts, which are cast up each month, giving the true situation. It may be well to note that these accounts show the complete situation.

(*a*) *The quick assets:* Cash on hand and accounts receivable.

(*b*) *The value of raw material* on hand. These figures give the proof of the whole cost system. We know the expense is accurate because we get it through the bookkeeping. We know the labor is accurate because we prove it with the pay-roll. In the material cost we depend for accuracy upon the correctness of storeroom reports, and foremen's reports where the material is not kept in the storeroom. But by deducting the monthly report of material used, we arrive at these accounts showing material we should have on hand, and an occasional inventory shows how accurate the reports are.

| Name | No. | Rate | Total hrs. | Total day work | Total piece work | Total pay | Non-prod. labor Hrs. | Non-prod. labor Amount | Order 7216 Hrs. | Order 7216 Amount | Order 7320 Hrs. | Order 7320 Amount | Order 7115 Hrs. | Order 7115 Amount | Etc. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| John Jones | 28 | $25.00 Wk. | | 25.00 | | 25.00 | | 25.00 | | | | | | | |
| B. Smith | 29 | 25¢ | 58 | 14.50 | | 14.50 | | | | 7.50 | | 7.00 | | | |
| T. Jackson | 30 | 30¢ | 68 | 17.40 | | 17.40 | | | | 5.40 | | | | | |
| S. Samson | 31 | 20¢ | 58 | | 15.72 | 15.72 | | | 30 | 7.50 | | 6.00 | | 6.00 | |
| P. Brown | 32 | 15¢ | 58 | | 8.70 | 8.70 | | 8.70 | | | | | 32 | 8.22 | |
| Etc. | | | Etc. | | | | | Etc. | | | | | Etc. | | |
| Total | | | | 279.36 | 72.89 | | | 62.50 | | 28.10 | | 25.00 | | 14.22 | Etc. |
| Expense 120% | | | | | | | | | | 33.79 | | 30.00 | | 17.06 | Etc. |

FIG. 236.—Pay-roll Book.

| | C Repair | Class C | B Repair | Class B | A Repair | Class A | Miscel. | Date | Item | Order No. | Miscel. | Iron cast-ings | Iron and steel | Lum-ber | Brass castings | Sundry material | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 15.00 | | | Iron Castings 500 Lb. | 7125 | | 15.00 | | | | | | |
| | | | 6.60 | | | | | | Brass Castings 20 Lb. | 7187 | | | | | 6.00 | | | |
| | | | | | 1.00 | | | | 100 Bolts 5/8×2 1/2 | 7289 | | | | | | 1.00 | | |
| | | | | Etc. | | 4.00 | | | 200 Ft. Spruce | 7016 | | Etc. | | 4.00 | | | | |
| | 20.00 | | 17.03 | 16.05 | 4.17 | 25.25 | | | Total | | | 22.10 | 7.18 | 17.00 | 26.12 | 10.10 | | |

FIG. 237.—Material Journal.

(*c*) *The monthly profit* on each line of machinery.

(*d*) *The cost of orders* in process by the lines of machinery.

(*e*) *The foundry profit* or loss. In this concern the foundry is operated as a separate plant, selling its product to the machine business at a slight advance over cost.

(*f*) *The liabilities.* So the situation is shown completely every month, just as if stock were taken; and the only chance for error lies in the material-on-hand accounts, which are checked occasionally by actual inventory.

| | Dr. | Cr. |
|---|---|---|
| QUICK ASSETS | | |
| Cash | | |
| Petty Cash | | |
| Bills Receivable | | |
| Accounts Receivable | | |
| MATERIAL ON HAND | | |
| Sundry Stock | | |
| Brass Castings | | |
| Lumber | | |
| Iron and Steel | | |
| Iron Castings | | |
| PERMANENT INVESTMENT | | |
| Real Estate | | |
| Machinery | | |
| COST UNFINISHED CONTRACTS | | |
| Class "A" | | |
| Class "B" | | |
| Class "C" | | |
| Class "D" | | |
| Class "E" | | |
| Class "F" | | |
| GENERAL PROFIT AND LOSS | | |
| General Expense Undivided | | |
| Interest and Discount | | |
| Income on Investments | | |
| Class "A" | | |
| Class "B" | | |
| Class "C" | | |
| Class "D" | | |
| Class "E" | | |
| Class "F" | | |
| Profit and Loss | | |
| FOUNDRY PROFIT AND LOSS | | |
| Sales | | |
| Metal | | |
| Productive Labor | | |
| Expense Used | | |
| Expense Undivided | | |
| LIABILITIES | | |
| Capital Stock | | |
| Surplus | | |
| QUICK LIABILITIES | | |
| Accounts Payable | | |
| Bills Payable | | |

FIG. 238.—Monthly Statement.

## SECTION VI

# TRAFFIC AND SHIPMENT CONTROL

## DUTIES OF A TRAFFIC MANAGER

**483. Duties of a traffic manager.** The duties of a traffic manager are, commonly, to take charge of all movements of freight, express, mail and parcel post, both incoming and outgoing. This necessitates an intimate knowledge of the various freight tariffs, and of the regulations of the Interstate Commerce Commission affecting traffic:

To obtain and quote the best and cheapest freight rates to customers.

To issue instructions as to the loading and routing of shipments to secure these rates.

To endeavor to secure the establishment of rates which will place his firm in as favorable a position as possible with regard to the movement of their goods.

To expedite incoming as well as outgoing shipments by means of tracing.

To present and follow up claims for loss and damage or overcharge, as occasion may arise.

**484. Freight claims.** Claims may arise through either *loss or damage*, or *overcharge*. In any case, the following papers should be presented to the claim agent of the road concerned, or other official designated to take care of such cases.

1. The original bill-of-lading, or a certified copy.
2. The original invoice, or a certified copy.
3. The claimant's invoice for the amount of damage.
4. Any necessary explanation or documents bearing on the case.

The prosecution of claims is an important item with any concern engaged in manufacturing and shipping. Large industries have a man employed for this purpose alone, and secure enough returns on his efforts as a rule to well repay them for the expense incurred. Small plants cannot afford a special employee for this purpose, but neither can they afford to overlook the return which may be secured from the proper presentation of claims, and should make provision to see that all claims which are just should be presented, however small they may be. The total amount of small claims extending over a period of several months often becomes a surprising item.

**485. Analysis of rail shipments.**

| | |
|---|---|
| *Scheduled trains.* Running at regular periods and using a repeated train number symbol. | *Passenger service.* Including express shipment; carload and less-carload; local and through.<br>*Fast freight.* Known in railroad language as "Red Ball" trains. Do not carry local freight except for transfer at a division point. Carload and less-carload.<br>*Local freights.* Usually running between division points and delivering freight at all scheduled stations. Further classified as: |
| *Extra trains.* Run under no definite schedule, and usually have the locomotive number for a train number. | *Regular.* Leaving daily at a definite time.<br>*Extra.* Leaving daily when a train can be made up.<br>Carry carload shipments both local and through. Extra trains carry less-carload shipments only when it is impossible to run them on scheduled trains. |

## CAUSES OF DELAY IN SHIPMENT

**486. Causes of delays of shipments in transit.** Among the common causes for delay in freight shipments are the following. The first two are due to the shipper and means should be installed to prevent their occurrence which is due to carelessness or poor management.

(*a*) In less than carload shipments, tags are often mutilated or destroyed, or the address becomes illegible due to the tag getting wet. These difficulties are met by using heavy linen tags, waterproof ink for addressing, insisting on legible writing, or installing tag-addressing machines which print the address of the consignee on as many tags as are required.

(*b*) Incorrect addressing of less than carload shipment tags, due to careless reading of the shipping bill, or to instances in which there are two stations of the same name in the state and the county is not shown. The remedy for these troubles is to print or write the tags in the main office and attach to the shipping bill.

(*c*) Not enough tonnage at junction points to make up a train for the particular class of freight involved. This is due to the fact that railroads insist upon their locomotives keeping up to a standard tonnage capacity haul.

(*d*) Too much tonnage in trains passing the junction point to pick up all cars standing at that point.

(*e*) Loss of credentials, such as way-bill, manifest, clearance papers, which are delayed in the mail or sometimes lost, and with, out which the car is not allowed to move.

(*f*) Delays caused by cars being set aside for weighing.

(*g*) Lack of room at team track at destination of the car, especially when there is an excess of perishable freight.

(*h*) Delays caused by custom inspection.

While but two of the above are preventable by the efforts of the shipper, a knowledge of those causes of delay for which the transportation companies are responsible is essential in order to trace shipments intelligently.

**487. Essential railroad records used in tracing freight shipments.**

### Carload Records and Reports

*At shipping point.* Car record: Kept by local freight agent, showing car number and initial (continuous record).

Copy of way-bill: Issued by local freight agent, containing point of origin, point of destination, date of shipment, complete route, name of shipper or connecting line reference, consignee's name and address, itemized list of the commodity, weight, rate and revenue.

Abstract of freight forwarded: Kept by local freight agent, showing car number, initial, consignee, commodity, weight and revenue (daily).

*At receiving point.* Abstract of freight received: Kept by local freight agent, showing car number, initial, consignee, commodity, weight and revenue (daily).

Original way bill for goods shipped, which is kept at local office until end of month and then forwarded to auditor of freight accounts. This shows how the shipment was handled at every junction point.

Freight bill: Issued from way-bill giving all information shown in way-bill except handling of shipment in route. Filed by "Pro" number, two copies being retained by local freight agent.

Passing records: Shipments received on through way-bills. Made by freight agent at junction points showing, in book record form, date received,

date of way-bill, number of way-bill, point of origin and destination, name of shipper and consignee, commodity, weight, rate and revenue (daily record).

Passing reports: Sent daily to division freight agent, showing car numbers and initials and train forwarding of all cars passing junction points.

Conductor's records: Conductor reports, for every train handled, car numbers and initials, commodity, consignee and destination. One copy to general car accountant, one to division superintendent, and other copies as required by the road.

Yard report: Made by yard clerk where cars are transferred from one train to another, in all trains passing through a yard at the end of a division. Kept in yard office.

### Less-carload Records and Reports

Same records made with less-carload as with carload and, in addition, the freight agent at both points of origin and destination, as well as junction point where car is transferred, make daily report of goods on hand in the freight house, showing nature of shipment and how marked. These reports filed in freight house.

## TRACING METHODS

**488. Methods of tracing rail shipments.** The old method of tracing, which is still largely used, was by means of return postal cards. This has largely been replaced by wire tracers, the telegraph being the most commonly used. The telephone is the fastest possible means of tracing, cars being located in a few hours that would take days to trace by other means, and is exclusively used by progressive shippers for all reasonable distances. Some shippers who are unfamiliar with tracing methods handle this work through the commercial agent of the road. He in turn hands it over to the freight claim agent of the road involved and the service obtained in this manner is slow. Many large concerns have found it to advantage to employ persons who act as tracers, especially at terminal points and who are acquainted with the various freight agents and individuals handling terminal cars. Their duty is to locate the cars and hurry them to destination for unloading. Their services are particularly valuable when material shortages are holding up work on large contracts, or are handicapping operations within the plant.

**489. General procedure in tracing.** (*a*) Get car number and initial.

Obtained from local freight agent at point of origin of shipment.

(*b*) Get train number and destination, also division points.

Obtained from the division superintendent's office at point of origin of shipment.

(*c*) Find if car has arrived at final destination.

By wiring to freight agent at destination point, giving him car number and initial, also train number.

(*d*) Trace at various division points, starting with last one.

By wiring to freight agent at that point giving the same information as above.

(*e*) Having located car between two division points, take up with superintendent of first division point beyond that at which trace of the shipment was had. If not effective of results within a reasonable period, take up with traffic manager.

**490. Fast freight, less-carload tracing.** Take up with local freight agent, referring to date of shipment and consignee. Duplicate bills-of-lading are filed by date in all freight offices. The freight

agent then refers to the way-bill to find routing, car number and initial and number and date of way-bill. The one tracing the shipment then should communicate with freight agent at destination point for advice as to date of delivery to consignee. In many cases, carting companies making mixed deliveries hold material in their barns. If the shipment has not been delivered to destination, the same procedure is then followed as for fast freight carload tracing, up to the point of locating it at the junction point shown in the way-bill. The "Passing Record" which is kept at junction points makes the matter easy when the car number and initial and train numbers are known. This method applies to through as well as local shipments, less than carload.

**491. Tracing shipments that travel via both fast freight and local less than carload.** Every car is provided with a card showing its destination. A record of this is kept by the local freight agent at the point of origin of the shipment. When shipments are made to points other than that to which the car is carded, the matter should be taken up with the local freight agent of the station which is designated as the carded destination. He will be able to advise car number and carding of the car into which the shipment was reloaded. And so on to point of final destination of shipment.

**492. Tracing carload local shipments.** This should invariably be handled exclusively through the division general superintendent.

**493. Tracing local less than carload shipments.** First, find out from local freight agent at destination whether the shipment has arrived. Then, having the car number and initial, ascertain from the division superintendent the train number and destination. Consult a railroad map for points between origin and destination which have connecting or branch lines. A form letter should be sent to each of these stations for information as to the handling of the shipment, which may have been placed off at any one of them in error. This procedure should be followed in tracing any shipment which is shipped for delivery via a local freight train.

**494. Tracing local shipments destined to prepay stations where there are no agents.** Tracing should be done as above, and form letters sent to the agents at the nearest points to the destination for advice as to delivery. This should also be taken up with the division superintendent, which insures that the train master follows the same procedure and renders the tracing more positive.

**495. Loss of less than carload shipments.** If unable to locate them through tracing, take up with freight claim agent as he keeps a record of every article found unaccounted for on his road.

*Special Tracing Procedure for Various Classes of Shipments*

**496. Express shipments.** Follow the general procedure outlined, except that information as to car and train number is obtained from local express agents instead of from freight agents or superintendent's office. In addition to this, in small towns with no wagon delivery, or where express packages become mislaid or sent to wrong stations, it is well to notify the general offices of the express company, since after 30 days it is customary for the local offices to return there all unclaimed or undelivered express parcels.

**97. Carload express shipments,** being accompanied by an indi-

vidual acting as messenger, seldom require tracing, as it is his duty to see that the car goes through without delay.

**498. Fast freight carload tracing.** Follow the general tracing procedure. If not effective, wire to general freight agent of the road concerned, giving him the record of the train and car with date of shipment, shipper's name, name of consignee, destination of shipment. This course may be continued, when necessary, through the traffic manager up to the president.

**499. Tracing shipments made over two or more roads.** There may be a terminal belt line which handles the car from one road to the other and which is not shown in any printed schedule. Inquiries should be made to the superintendent of the delivering road as to this. The case is then put to the traffic manager of the belt line concerned, giving car number and initial, and date of delivery to his road.

**500. Tracing materials shipped from points of unknown origin.** Commodities such as lumber which is bought from commission dealers or brokers is often shipped from points unknown to the consignee. The procedure in this case is as follows:

Get car number and initial from the broker, who always has this information. Then communicate with the car accountant of the road owning the car in question. He will be able to tell within 2 or 3 days what road has the car, from which point the tracing may be carried out under regular methods.

**501. Tracing lumber and other materials which have storage in transit privileges.** Material of this sort being usually purchased through a broker, the same procedure as above is followed up to the point where the material in question was stored in transit. Information must then be had from the storing company as to the car number and disposition of the reshipment, after which the regular procedure is continued. If this is not effective, the case should be taken up with the general car accountant of the road over which the car was reshipped.

**502. Tracing shipments sent on an extra train.** The same procedure is followed in this case as for fast freight shipments, both for carload and less than carload.

**503. Terminal tracing.** Local freight agent of the terminal of first road should be requested to advise if such shipment is "over" in his freight house. If not, he will advise the delivery to connecting line, and state whether delivery was made by team, intermediate belt line, or direct. If transfer has been made to another road, the local freight agent at the terminal of the first road should advise the car number and routing, and upon request will give the name of the intermediate road used. The matter should then be taken up with the freight agent of the road which is to receive the freight, the freight house ascertained which does the actual transferring, and communication sent them. If delivery is by team, an agent of the first road should have a receipt for delivery of the material to the second road, providing this has taken place. In all cases where shipments are lost 30 days or more, a report should be filed with the claim agent so as to be within the 4 months limit provided in the tariffs.

It should be remembered that the train symbols are changed at junction points, whereas the car number and initial remain the same.

**504. Operating and erecting instructions sent with shipments.** These are likely to be overlooked unless fastened directly to a part of the machine. They should be fastened with wire, and to prevent them becoming blurred with grease and unreadable, it is well to have them printed on grease-proof paper. Instructions which are intended to be given the operator of the machine are more likely to be preserved and used if they are mounted on cardboard and varnished and provided with a hole by which they may be hung up. Some firms make a practice of sending out two sets of instructions, one with the shipment, and the other by mail with the invoice, especially where trouble is likely to result if instructions are not followed. This practice makes it impossible for the purchaser of the machine to say that he received no instructions. Instructions should not be too diffuse or complicated or they will not be read. It is better to state plainly the most essential things that should or should not be done, and leave the rest to common sense, than to go into details that will be passed over as "red tape."

## SECTION VII

# SHOP HAZARD CONTROL

## SAFETY

**505. Safety.** The consideration of safety of employees divides itself into three heads:

(*a*) The prevention of accidents.

(*b*) The prevention of fire.

(*c*) The prevention of sickness and ill health, or sanitation.

The prevention of fire has always been considered of considerable importance by manufacturers, possibly owing to the fact that their interests were quite obviously connected with it. The prevention of accidents is now receiving attention in proportion to the merit of the cause, largely through popular and legislative movements. The prevention of ill health due to working conditions is also becoming a more studied subject, although it has not reached as yet the prominence attained by the other two.

The extension of safety in industry is sometimes regarded as a "welfare" activity which places it on the basis of a more or less "charitable" undertaking. This viewpoint is entirely wrong, it being a strictly business proposition, and one paying dividends in proportion to the intelligence and effort applied to it.

**506. Analysis of accidents in a machine shop.** The table, Fig. 239, presented by Luther D. Burlingame, of the Brown & Sharpe Co., gives the analysis of accidents in that plant for a period of 5 years, from 1905 to 1910. It may be taken as typical of the average division of injuries, although different plants will differ in this respect according to the physical arrangements, and nature of the work.

| | Total accidents | Per cent. |
|---|---|---|
| Caught in machinery | 78 | 7.0 |
| Caught or struck by belt | 23 | 2.0 |
| Setscrew or other projection | 29 | 2.6 |
| Falling on or striking workman | 226 | 20.1 |
| Workman falling or strained in lifting | 75 | 6.7 |
| Machinery starting unexpectedly | 8 | 0.7 |
| Chain or rope slipping or breaking | 10 | 1.0 |
| Punch press, rolls, or shears | 20 | 2.0 |
| Cutters and metal saws | 94 | 8.5 |
| Handling work or chips—eyes | 126 | 11.2 |
| Wood-working machinery | 47 | 4.2 |
| Burns, including electricity | 79 | 7.0 |
| Cuts with sharp instruments | 20 | 2.0 |
| Jams and hammer blows | 71 | 6.3 |
| Caught in tool and work (not cutters) | 176 | 15.7 |
| Elevator | 4 | 0.5 |
| Fooling | 13 | 1.2 |
| Litter or dark places | 15 | 1.3 |

FIG. 239.—Analysis of accidents at Brown & Sharpe's.

## MECHANICAL SAFEGUARDS

**507. Mechanical guards.** Actual prevention of a great many accidents is attained by the use of proper guards for the dangerous elements. A list of these, which appeared in the American Machin-

ist, vol. 36, p. 273, is given by John Calder, manager of the Remington Typewriter Co. They are as follows:

1. All engaging toothed or other gears, rolls, drums and slides of every description on the machine.
2. The spaces between fixed and moving parts at any machine, or between the latter and structures near it, leaving insufficient working clearance—in no case less than 18 inches—for any person employed thereon or near it.
3. Pulleys and clutches.
4. Belts, bands and driving chains.
5. Flywheels and starting balance wheels.
6. Shafting and spindles and all couplings or projections thereon or upon reciprocating or other moving parts of machines.
7. Counterweights and balance gears and other suspensions.
8. The actual element on every machine which comes into contact with the work, and cuts, shears or otherwise operates upon the latter, for instance the circular saw blade on the sawmill, the punch and die in the press, the revolving cutter in the miller.

Mechanical guards go a long way toward the prevention of accidents in connection with these dangerous members. The guarding of many of these is compulsory by state law, which should not be regarded as, however, taking the place of the initiative of the manufacturer or management in this respect. The state inspections are not always thorough owing to the lack of sufficient men to make them. The management should, in addition to safeguards which are called to its attention by state inspectors, make an analysis of every machine in each department according to the list of dangerous elements given above, and see that they are suitably protected. The form of protection used varies considerably.

**508. Gear guards.** In purchasing new machines it is always well to insist on the proper guarding of gears by the manufacturer. This is not asking anything unreasonable since it is done by the majority

FIG. 240.

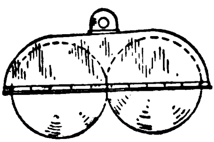


FIG. 241.

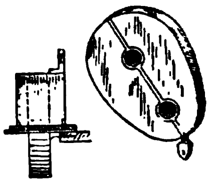


FIG. 242.

Methods of guarding gears.

of progressive manufacturers at the present time. Cast-iron enclosing guards are preferable. Sometimes the line of mesh only is guarded in an effort toward economy of metal. In this case accidents are likely to result by clothing or flesh being caught between the guard and the gear, and to avoid this the clearance of the guard at this point must be a minimum. (See Fig. 240.)

Cast-iron guards are out of the question when the purchaser has to supply them, as in the case of old machines without guards, since their use entails considerable expense for patterns. In this case, sheet-iron guards will do as well if they are properly made. A sheet-iron gear guard is illustrated in Fig. 241. Owing to the flexibility of the metal it is advisable to reinforce the edges of large sheet-iron guards with angle iron or half round strips.

Guards must be readily removable for purpose of inspection and repair, so that time is not lost in detaching them. In some cases guards are locked against removal as shown in Fig. 242, only those authorized to remove them having keys for this purpose.

**509. Belt guards.** Belts which are out of reach, such as overhead belts and machine driving belts running on machine cones above the height of the operator's waist line, are not usually guarded. The danger in connection with the overhead belts lies in throwing them off and on, which should not be allowed without shutting down the driving motor. Machine driving belts running on cone pulleys are usually shifted by hand without much chance of danger or injury to the operator except from belt hooks or wire lacing, which should be avoided on this class of belts. Belt shifters are on the market which eliminate the possibility of danger in shifting from one step to another by doing it mechanically.

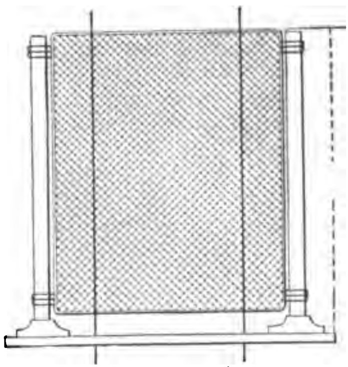


FIG. 243.—A vertical belt guard.

Vertical belts should be guarded to a height of at least 4 feet above the floor line, preferably by means of the type of guard shown in Fig. 243. This is made of wire netting with supports made of pipe or angle iron. One side is made removable for belt repairs.

Horizontal belts should not be run at a height of less than 7 feet from the floor line, owing to the difficulty of properly guarding them, and to the danger of injury by walking into them.

Angular belts must be guarded to a height sufficient to protect those walking under them, which is more than the 4-foot requirement for vertical belts in cases where the angle is large.

**510. Punch and shear guards.** Accidents which result from this class of machinery are usually serious in their effect on the future capacity of the operator. They may be avoided almost altogether by the use of hand-starting pedals instead of the customary foot pedal. In this case, devices are employed so that the operator must use both hands to trip the machine. Unfortunately this reduces production by increasing the number of hand motions necessary, and there is a tendency on the part of pieceworkers to object to this arrangement. This should be met by the company with readjustment of rate and insistence on their use, the increase being chargeable to the accident prevention account.

**511. Quick-stopping devices.** On machines such as bending tools, the operator is frequently at a considerable distance from the starting and stopping means. Serious and deplorable accidents result on this class of machinery which are preventable by arranging stopping devices so that they may be operated from any point by

the weight of the man's body, or the pressure of his foot. Where this is impractical, it should be insisted upon that two men work together, one of whom should always be at the stopping lever.

In some machines danger is encountered after the shift is tripped on account of the inertia of the moving parts which do not come to rest quickly. In some cases, brakes are provided which go into action with the stopping trip, bringing the machine quickly to a standstill. The use of brakes is not general on machine tools, but will possibly be extended in the future, not only because of making them safer, but to do away with delays and lost time.

**512. Overhead shafting and bearings.** Oiling the overhead works is a dangerous business, as it is done ordinarily with the machinery in motion, or at best, one machine stopped at a time while oiling its countershaft. Large self-oiling bearings for shafting reduce the number of times that they require oiling, thereby working toward safety as well as economy. Loose pulley oiling is a dangerous proposition which is rendered safer by the use of grease or "candle" lubricators which do not require much attention. Ladders with spikes or claws on the feet and long-spout oil cans work toward safety for the oiler. A modification of the long-spout oil can is a device with pump attachment which is carried about and operated from the floor, requiring no ladder, but having an extension spout long enough to reach the overhead bearings where the factory roof is not high.

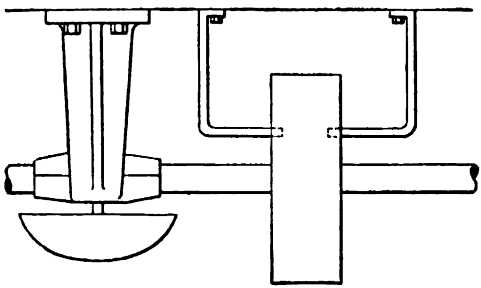


FIG. 244.—A belt hook.

Protruding setscrews are prohibited on the overhead works, and should be on all moving parts. Something less obvious is the sharp-edged collar from which severe cuts are sometimes received. Belt hooks, shown in Fig. 244, prevent belts from winding up on the shaft in case they are thrown from the pulley intentionally or otherwise.

**513. Driving dogs.** The common type of lathe dog is a dangerous proposition and is rapidly being discarded in favor of safer types without protruding screws.

**514. Guarding emery wheels.** Emery and grinding wheels are dangerous in two respects, first through breakage while running, and second from the chips thrown off. Guards which will protect against breakage of the wheel and yet allow of sufficient opening for working purposes are hard to devise, especially in connection with exhaust hoods for removing the dust and chips. Comparatively few wheel accidents are caused by defective wheels since careful inspection is made as a rule before shipping, and the recommended

speeds are well within the safe limits. The table, Fig. 245, covers the ground of grinding-wheel accidents very fully.

**515. Goggles** are not only of use at grinding wheels, where they should be insisted upon, but are of service in protecting the eye from flying chips in the chipping department, and also when turning brass or other material where flying chips predominate.

Where tool grinding is done by various ones at a general department wheel, some plants make a practice of keeping a pair of goggles in a box at the wheel and insisting that they be used.

**516. Exhaust systems for emery and buffing wheels** are necessary to protect the operators against flying particles, also to keep grit from settling upon neighboring machines and resulting in wear by grinding action.

The Buffalo Forge Co., in their handbook entitled "*Fan Engineering*," makes the following recommendations respecting grinding exhaust systems.

### Grinding Wheels

| Diameter of wheels | Maximum grinding surface, square inches | Minimum diameter of branch pipe in inches |
|---|---|---|
| 6 in. or less, not over 1 in. thick | 19 | 3 |
| 7 to 9 in. inclusive, not over 1½ in. thick | 43 | 3½ |
| 10 to 16 in. inclusive, not over 2 in. thick | 101 | 4 |
| 17 to 19 in. inclusive, not over 3 in. thick | 180 | 4½ |
| 20 to 24 in. inclusive, not over 4 in. thick | 302 | 5 |
| 25 to 30 in. inclusive, not over 5 in. thick | 472 | 6 |

### Buffing Wheels

| Diameter of wheels | Maximum grinding surface, square inches | Minimum diameter of branch pipe in inches |
|---|---|---|
| 6 in. or less, not over 1 in. thick | 19 | 3½ |
| 7 to 12 in. inclusive, not over 1½ in. thick | 57 | 4 |
| 13 to 16 in. inclusive, not over 2 in. thick | 101 | 4½ |
| 17 to 20 in. inclusive, not over 3 in. thick | 189 | 5 |
| 21 to 24 in. inclusive, not over 4 in. thick | 302 | 5½ |
| 25 to 30 in. inclusive, not over 5 in. thick | 472 | 6½ |

### Recommendations

1. Emery wheel and buffing wheel exhaust systems should be kept separate owing to danger of sparks from the former setting fire to the lint dust from the latter if both are drawn into the same suction main.

2. In the case of undershot wheels, where the top of the wheel runs toward the operator, which is almost always the direction of rotation of both emery and buffing wheels, the main suction duct should be back of and below the wheels and as close to them as is practicable; or it should be fastened to the ceiling or the floor below, preferably the former. If behind the wheels, it should be not less than 6 inches above the floor at every point to avoid possible charring of the floor in case of fire in the main duct and also to permit sweeping under it. For similar reasons it should be at least 6 inches below any ceiling it may run under.

3. Both the main suction and discharge pipes should be made as short and with as few bends as possible, to avoid loss by friction. If one or the other must be of considerable length, it is best to place the fan not far

beyond where the nearest branch enters the large end of the main, as a long discharge main is a less evil than a long suction main.

4. Avoid any pockets or low places in ducts where dust might accumulate.

5. The main suction duct should be enlarged between every branch pipe entering it, whenever space permits, and in no case should the main duct receive more than two branches in a section of uniform area. All enlargements in the size of the main should be made on a taper and not by an abrupt change.

6. If there is a likelihood of a few additional wheels being installed in the future, it is advisable to leave a space for them between the fan and the first branch and to put in an extra size fan. Or, a space may be left beyond the fan so that the fan may be moved along and the main extended when it is actually decided to install additional wheels, provided the fan is of sufficient size to still comply with these specifications after the additional branches are added.

7. Branch pipes should enter the main on the top or sides—never at the bottom. Two branches should never enter a main directly opposite one another.

8. Each branch pipe should be equipped with a shut-off damper or blast-gate as it is also called, which may be closed, if desirable, when the wheel is not in use. Not more than 25 per cent. of such blast-gates should be closed at one time; otherwise, the air velocity in the main duct may drop too low and let the dust accumulate on the bottom.

9. It is important that the lower part of the hood shall come far enough forward beneath the front of the wheel so that the dust will enter the hood and not fall outside of it altogether, even if the accomplishment of this result necessitates leaving considerable space between the wheel and the lower part of the hood so that the hood shall not interfere with the work.

10. Branch pipes should lead out of the hood as nearly as possible at the point where the dust will naturally be thrown into them by the wheels. This is very important.

11. An objectionable practice sometimes found where small work is polished is the use of a screen across the mouth of the branch pipe where it enters the hood. Such screens are an obstruction to the passage of material, and the ravelings from buffing wheels are held against the screen by the suction, with the result that in a short time the draft is almost entirely cut off.

12. The use of a trap at the junction of the hood and branch pipe is good practice provided it is cleaned out regularly and not allowed to fill up with dust. This will catch the heavier particles and so take some wear off the fan. It will also serve to catch any nuts, pieces of tripoli, and the like, dropped by accident, and in the case of work on small articles, will enable them to be recovered when dropped in the hood.

13. All bends, turns, or elbows, whether in the main or branch pipes, should be made with a radius in the throat of twice the diameter of the pipe on which they are connected, wherever space permits.

14. Elbows should be made of metal one or two gages heavier than the pipe on which they are connected as the wear on them is much greater.

15. The withdrawal of air from a room by an exhaust system naturally tends to create a slight vacuum and for this reason inlets for air at least equal to the sum of the areas of the branch pipes should be left open.

16. Recommendations for the size of the cyclone separator or dust collector, as it is often called, are hard to give, as the separator must be proportioned to suit operating conditions, light dusts requiring a larger separator than heavier dusts. A separator should be selected with an inlet area at least as large as the area of the discharge pipe from the fan.

For light buffing dusts, lint, and the like, the air outlet from the top of the separator should be so large that the velocity of discharge will not exceed 300 to 480 feet per minute; then select a separator of which the other dimensions are proportionate. The air outlet should be provided with a proper canopy or elbow to exclude the weather, but should be otherwise unobstructed.

**517. Wood-working machine guards.** This class of machinery often found in connection with machine shops where pattern and carpenter departments form a part of the plant, gives rise to a large percentage of accidents. It is here that the guards must be kept in constant use and watched most closely, for there is a tendency

on the part of the workman to ignore the risk and put them to one side. Circular saws should be provided with adjustable hoods which cover the exposed portion of the blade to within a distance from the worktable equal to very little more than the thickness of board to be cut. Planers and jointers should be provided with guards which cover all portions of the knife which are not cutting, and preferably with knives of flush construction on round arbors instead of the common square arbor and knife that sticks out from ½ to ¾ in. Operators should be frequently cautioned to stand to one side of the machine and not directly back of the work being fed, since a kick back caused by striking a knot has often proved fatal. Band saws should have both upper and lower wheel completely enclosed, also all of the saw track with exception of a few inches above the table, so that in case of breakage the saw cannot whip or fly.

**518. Warning signals.** Aside from mechanical guards which prevent injury are warning signals which warn against danger. The commonly accepted danger signal is the red disk, objected to by some on account of the inability of the color blind to distinguish it from green, the safety signal. In addition there are other signals used for this purpose, one of them being the skull and cross-bones in red on a white ground, which is used where the class of intelligence is low. Red lights take the place of red disks in dark places.

*An important precaution* is to set a warning on the main valve of a boiler when a workman is inside cleaning it. Better still, an enclosing case is provided and locked with a padlock.

A large percentage of accidents are caused by falling articles. To guard against this, warning signals should be set below the source of danger, or the area may be roped off.

**519. Proper lighting.** Effective lighting is in line with the safety movement especially in dangerous places such as at the top of a dark stairway. General recommendations regarding shop lighting are given in (175).

**520. Guarded platforms and scaffolds.** To insure safety, platforms and scaffolds should be provided with a back rail consisting of two strips, the lower at a height of 8 to 12 inches above the platform, and the top strip from 28 to 36 inches above the platform. Permanent scaffolds should be attached to each overhead traveling crane for the safety and convenience of the oiler and electrician. A landing platform should be provided for the craneman, and his ladder should preferably be set 16 to 18 inches away from the wall so that he may climb on the inside, between the wall and the ladder.

**521. Safety first movement.** Mechanical devices to prevent accidents are not effective unless followed up by constant watching to see that they are used, and given general attention by all department heads and executives. Each one in authority must be impressed with the necessity of reducing the number of accidents in his department, and must in turn impress his subordinates with the necessity of using care. Prizes are sometimes offered as an inducement to extra effort toward a reduction in the number of accidents.

**522. Physical examination of new employees** is usually under-

taken at the expense of the employer in those states where comp sory compensation for injuries is in effect. Sometimes, the wo man is required to bear the expense and furnish a certificate physical condition from a reputable doctor. The value of a physi examination of employees is not only a guarantee to the emplo that he will not be called upon to compensate for old injuries ceived before hiring the man, but it has the additional advant of telling him what he is getting in the way of general physical ma up. This is of considerable value and is worth the cost of the exa nation required.

**523. Safety leaders.** Where the safety movement is taken in earnest, some one individual is usually appointed as a guidi spirit. In addition, safety men are distributed among various partments, these having received some education along the li of accident prevention, and being naturally of a cool and car disposition. Sometimes this is carried as far as to appoint a m in each gang as the "safety man." This is especially effecti among gangs of laborers and those engaged in construction wo

Oftentimes the work of accident prevention devolves upon t already overworked foreman or department head. In that ca he will do well to perfect a safety organization within his own partment to relieve him of part of the burden. The following a set of safety rules for foremen, which will apply to the sm plant where he has time to attend to these matters in detail.

### 525. Safety Rules for Foremen

Learn all safety rules for workmen. You will be held responsible for t enforcement of all these rules in your department.

When you hire a new man, you must explain to him all safety rule connection with his work.

When you put a man on a new class of work, explain to him all saf rules in connection with his new work.

Watch all new men carefully and see that they take no unnecessary ri

You are responsible for keeping in place all safe-guards in your departme

If a new machine is set up in your department, do not allow it to be star until you make sure that all gears and other dangerous parts are protec

If a machine has been repaired, do not allow it to be started until gua have been replaced.

If a guard or safety device is out of order, do not use machine until been repaired.

Keep all passages and fire exits in your department clear at all times.

See that all waste material and sweepings are taken from your departm before leaving at night.

See that all fire apparatus in your department is kept clear and alwa ready for instant demand.

**526. First aid.** No matter how small the shop, it is necessary have materials on hand with which to treat minor injuries. It also desirable to have a private room where those who are injur may go to be treated and those seriously hurt will be secluded fr a crowd of fellow employees.

Plant first-aid rooms vary in completeness from a corner in t stock or storeroom containing a cupboard with a few necess remedies and bandages to a hospital suite completely fitted with sanitary furniture and attended by nurses and surgeons. T latter is possible only in the larger plants. The small plant mu depend for medical attention upon a nearby doctor. In order

## 524. Table of Causes of Grinding-wheel Accidents.

Prepared by the Independence Bureau of Inspection of Philadelphia for general distribution

- Flying wheel unbroken (caused by)....
  - ...by)..........
    - Improper inspection of wheel... { Before issued to operator. When being mounted.
  - Weakened wheel (caused by)—
    - Wheel untrue.
    - Wheel standing in water (see above).
    - Side grinding (see below).
    - Heating wheel (see above)
  - that nut works loose (caused by)..........
    - Belt twisted
    - Motor reversed.......... } Ignorance.
    - Spindle turned end for end.......... } Ignorance.
- Work or dresser hurled out of workman's hand (caused by)..........
  - Caught between rest and wheel. } See above.
- Flying particles of emery, inhaled or in eye (caused by)....
  - Exhauster defective (caused by)..........
    - Entire lack of exhauster.......
    - Exhauster line not proper size...
    - Exhauster line stopped up.....
      - Exhauster not provided.
      - Exhauster disconnected.
      - Ignorance.
      - Desire for saving expense.
      - Not often cleaned.
      - Poorly designed or constructed.
  - Eye protection insufficient (caused by)....
    - No goggles provided.
    - Improper goggles provided.
    - Goggles not used.............
      - Prejudice.
      - Carelessness.
      - Fear of infection.
  - Chip guard defective (caused by)..........
    - No chip guard.
    - Chip guard not in use.........
      - Broken and not replaced.
      - Prejudice of workmen.
- Flying pieces of broken revolving type of dresser (caused by)..........
  - No guard for dresser.

FIG. 245.

(Facing page 352)

insure his attendance in case of emergency his office hours should be posted for easy reference, as well as his telephone number and address. The doctor is sometimes selected by the liability insurance company and sometimes is the physician employed by the mutual aid association of the shop, in the latter case he will be found more apt to suit the majority of employees who regard the liability insurance companies as their natural enemies.

**527. A good arrangement** for a medium-sized plant where injuries have to be re-dressed daily is to have the doctor call daily at the plant for this purpose at a certain specified time. Where this is not done, the employee is allowed to go to the doctor's office on company's time, more of which is spent in this way than when the doctor calls. This applies to those who have been injured but not sufficiently to keep from working and the average number of such injuries will determine the policy in respect to a doctor.

**528. Subsidiary first-aid stations.** In large plants covering considerable area first-aid cabinets are distributed at several points. These contain stretchers, blankets, remedies for burns and scalds, and other immediate restoratives. Time is thus saved in taking the man to the first-aid room in serious cases, and minor cases are treated locally. Hot water is an almost necessary convenience at these points.

## FIRE PREVENTION

**529. Importance of fire prevention.** The importance of fire prevention is often not realized until after the loss has occurred. It is not only for the safety of the occupants of the plant that attention should be given this subject, but because of the great loss which attends a fire that destroys records and patterns and interrupts production, which cannot be covered by insurance, no matter how fully the plant is covered.

**530. Fire prevention** is aided and effected by the following:

(*a*) Automatic sprinklers.
(*b*) Fire pumps of sufficient capacity.
(*c*) Organization of fire brigade.
(*d*) Frequent drills.
(*e*) Frequent inspection.
(*f*) Proper fire-fighting appliances.

Plants located in large cities may omit the organization of a fire brigade which is designed to render the service during a fire that will be given by the city department.

**531. Automatic sprinklers.** An automatic sprinkler system is the best insurance against fire. A large majority of fires starting are extinguished by them without the necessity of other effort. Sprinkler systems in general are of two kinds, known as the "wet" and the "dry." In the former the sprinkler pipes are always filled with water under pressure ready for immediate use when the sprinkler head operates through rise of temperature. With the dry system, the pipies are filled with compressed air which must escape before the sprinklers deliver the water. The dry system is slower in getting into action, but is preferable in plants where there is danger of freezing of the pipes in winter.

The method of supplying sprinkler systems with water under pressure varies according to the height of the building and the city water pressure available. Frequently tank or standpipe service is provided in which case the bottom level of the tank should be at least 20 ft. above the roof of the highest building served.

**532. Colors to distinguish nature of piping in plant.** To make it more convenient to trace pipe lines through the plant, they should be painted different colors according to a color schedule. The following is an example:

Red: Fire lines and sprinkler system.
Black: Service water supply.
Yellow: Compressed air lines.
Blue: Gas lines.

Valves should have tags attached stating the function and departments served.

**533. Organization of factory fire brigade.** For the average shop plant there should be three separate companies; hose, chemical engine and ladder. Where buildings are provided with a complete equipment of stationary ladders the latter may be dispensed with.

In addition a special detail should be designated to handle chemical extinguishers, fire pails and any other equipment.

**A salvage corps,** consisting of from 6 to 12 men should be maintained, whose special duties should consist of protecting stock and machinery from water damage.

For captains of companies, men with mechanical knowledge are to be preferred, either shop foremen or regularly employed mechanics.

**Hydrant men.** Two men should be selected for each hose stream. One man to remain at the hydrant to turn the water on and off, the other to assist in unreeling hose, making couplings and taking out the hose.

**Pipe director and pipe men.** Three men are required for each hose line, one to be designated as the "pipe director" in charge of the pipe, the two additional men will be necessary in placing and moving the pipe and in drawing the line up ladders and over roofs.

**Chemical engine company.** To consist of five men, including a captain. Two tankmen should have charge of operating the engine tank; to open and close the main-tank valve in addition to agitating and mixing the chemical charge, and of recharging.

**Nozzlemen.** Two men should be selected to carry and direct the nozzle, and to assist in laying the hose line. For engines having two tanks, an additional tankman and nozzle-man should be provided.

**Standpipe company.** For factories, equipped with an interior standpipe system, a separate company should be organized to operate it and handle the hose lines connected therewith. Where standpipe systems are supplied from gravity tanks or by means of connections with public mains, the organization should provide for a "main valveman," who shall be charged with the duty of seeing that the shutoff valve between the source of supply and the standpipe system is open and in good working order.

Attached to each fire-brigade organization there should be an experienced plumber, preferably one familiar with the distribution system and with the location and operation of all valves. Where electric current is used, provision should also be made for the attendance at all fires of a practical electrician, having first-hand knowledge of all conductors, their voltage and of the location and operation of all protective devices.

At plants where the fire service is supplied by pumps, it is advisable to have the engineer in charge and his assistants enrolled in the fire brigade that they may be in close touch with the purposes of the brigade. During fires and drills, the engineers and assistant should remain on duty at the pumps.

**Fire drills.** (Ex Chief Croker in American Machinist, vol. 39, p. 793.) All drills should be subject to the direction of a supervisory organization as follows: Chief of fire drill, floor chiefs, room captains, stairway guards and inspectors.

**Duties of floor chiefs.** The floor chief should have charge of all operators employed on his floor in all matters pertaining to drills. He should see that each movement corresponding to the alarm signal is promptly and orderly executed, and personally supervise the sounding of the general building alarm on his floor. He should be responsible for the condition of aisles and passageways and should see that chairs, benches and stock are promptly removed to insure unobstructed passage.

When it may be necessary to depart from the regular instructions as regards selection and use of exits, such change should be at the sole direction of the floor chief.

**Duties of room captains.** They should perform the same general duties in their respective rooms as are prescribed for the floor chief, excepting that they should have no authority to change the assignment of exits, nor sound the general building alarm, unless under direction of the floor chief. Where rooms are equipped with drill gongs the room captains should personally sound the alarm thereon.

**Duties of guards.** Guards should be subject to the orders of the floor chief or room captains and should see that the march from the rooms and descending the stairway is orderly. They should be stationed as follows: One guard on the stair side of the door leading from the room and one guard midway on the staircase leading to the floor below. Where stair exits have sharp bends, or are poorly lighted, additional guards should be provided as required.

**Inspectors.** An inspector should be appointed to examine, each morning, the condition of all stairways, fire escapes, and roof exits, and to report to the chief of fire drill any obstruction found thereon or other unusual conditions. He should see that all doors leading to stairways open outwardly and immediately report any found locked or obstructed.

During the winter attention should be given to fire escapes exposed to accumulations of ice or snow.

In addition provision should be made for inspection each morning of the alarm system and of all signaling devices.

Someone should be appointed to make weekly inspections of the plant for the purpose of observing whether the general cleanliness

is in accordance with the instructions, and to see that all fire appliances are in good order.

An inspection book may be provided, in which the items needing attention shall be noted.

**Fire pails** should be checked as to location, whether they may or may not be filled with water.

**Fire extinguishers** should have a tag, on which should be noted the date when last charged and the covers should occasionally be removed to ascertain whether they need attention. If the bottle, which was originally half filled with acid has absorbed moisture, so that it is found three-quarters full, it is time to recharge.

**Fire doors** should be examined, to see that hinges and latches are in good condition, and the fusible links on self-closing doors should be examined, for it frequently happens that these links break and a piece of wire may be used for their repair, preventing the self-closing in case of fire, and materials are many times found placed so that the door cannot be closed.

**General cleanliness** of the shop should be noted and particular attention given to the accumulation of rubbish or oily waste.

Windows, or avenues leading thereto, should not be obstructed by stock, making it impossible for employees to escape, or the fire department to gain entrance. Fire-alarm and watchman's boxes should always be accessible. Oily waste should never be allowed to accumulate, and proper receptacles should be provided for holding it until gathered up and burned.

Too much care cannot be exercised in checking up electric wiring, particularly lamp cords, which are often found hung over a revolving shaft. Each plant has its own particular hazardous points, which should be listed and checked in addition to these general suggestions. A memorandum of defects should be promptly given to the proper authority, who should see that they are corrected without delay.

**534. Windows should be partly opened** from the top to ventilate the floor, and thereby aid in treating and extinguishing a fire should one originate in some corner of a ceiling or basement.

The names and duties of all persons selected to man the various auxiliary fire appliances and their relative substitutes (which must be permanent) are legibly written or printed on cards, and these cards are conspicuously placed throughout each floor with words of warning written or printed upon them in display form, as follows:

"NOTICE!!! THIS CARD MUST NOT BE MUTILATED, MARKED, DESTROYED, REMOVED, OR REPLACED ELSEWHERE, UNDER PENALTY OF FINE OR IMPRISONMENT!

In the event of fire immediately send in an alarm by operating the nearest fire-alarm box. Telephone without delay to fire headquarters and send in an alarm from an auxiliary box or the nearest city fire-alarm box.

*When the alarm apparatus sounds* in the room operatives must:

Stop work.

Shut off power.

Stop machines.
Shut off gas and other open flames.
Close doors and windows opening upon or under fire escapes.
Put chairs, tools and other obstructions on top or under benches to clear the passageway.
Form line promptly with front of column facing the usual egress aisle and wait for word of command from floor captain.
At the command to march, march in an orderly manner from the building, two abreast as instructed, not crowding upon the couple in front, and following the aisle leaders.
Preserve the interval in line between yourself and the couple in front of you.
Retain formation until dismissed, or until the line is returned to building.
Women always have the right of way.
Don't run.
Don't lag behind, breaking up columns.
Don't scream or make unnecessary noise.
Don't laugh or talk.
Don't cause confusion.
Don't remain in toilet or dressing rooms.
Don't return for your clothing.
Don't try to use elevators.
Don't attempt to leave the building except in accordance with fire-drill regulations.
Don't fail to assist in carrying out instructions.

**535. In all buildings used for manufacturing** or for business of any kind, auxiliary fire appliances should be installed, such as 40-gallon chemical fire engines on wheels, which can be rapidly taken from one floor to another and used with great effect on a fire even of considerable magnitude; and 3-gallon fire extinguishers which are operated by turning the machine upside down and which are more effective than the ordinary 10- or 12-quart water pail. Few, if any, laymen can use a water pail with proper effectiveness, while anyone can operate a 3-gallon extinguisher, which will throw a stream in any direction from 30 to 40 feet.

Regulation 6-feet fire hooks, for use in tearing down curtains, draperies or stock which may be on fire, and 5-pound flat-head fire axes for cutting into the floor where fire may have occurred owing to defective insulation or from other causes, will prove useful.

Every building four stories or more in height should be equipped with a standpipe ranging from 2½ to 6 inches in diameter, with a hose outlet on each floor. To each of these outlets should be attached from 50 to 100 feet of either unlined linen or single-jacket cotton rubber hose that will stand a pressure of from 350 to 400 pounds to the square inch for a period of at least 3 years. Where volatile or inflammable oils or electricity are used in any form, there should be provided an extinguisher filled with carbon tetrachlorate, and under 70 pounds air pressure.

Galvanized cans for alcohol, benzine, turpentine, etc., and self-closing cans for the reception of oily waste and rubbish, should be on every floor of every factory building.

*Where fire-doors are a part* of the construction an automatic door-release should be a part of that door, so that in case of a fire originating even from a newspaper, the sudden rise of heat will instantly operate this unit and close the door, no matter whether 200 or 5000 pound in weight, within 1 minute of the origin of the fire.

An approved sprinkler system or automatic fire-alarm operated by a sudden rise of temperature, rather than a fixed temperature device, should also be installed in factory buildings for quickly detecting and holding a fire in check until the arrival of the fire brigade of the local fire department.

The abolition of portable kerosene and oil lamps in every form is strictly recommended, as there are now in the market various electric lamps weighing but little and lighting with either a wet or dry system. These can be purchased very cheaply, and the cost of maintenance is small. These lamps are able to penetrate fog or smoke, and obviate the danger of oil lanterns.

Where there are 25 or more employees above the first floor of any factory building an approved interior manual fire-alarm system should always be installed for warning the employees in case of fire, panic or accident and for use in fire drills.

**536. Compensation for injuries.** In many states compensation is compulsory and of a definite amount. This compels the manufacturer to insure his employees which is done either in state insurance, mutual or other companies. Sometimes the employer carries his own risk in the matter, insurance not being compulsory. The amount of compensation varies in the several states and may be found by reference to state laws on the subject.

Where compensation is not compulsory, the right-minded manufacturer has often anticipated the law by voluntary compensation arrangements in which he either pays the whole cost of insurance or divides it with the employees. Sometimes the employees assure themselves of compensation by the formation of mutual aid societies which are also extended to cover sickness and death. This is done either with or without the coöperation of the company, although in most cases with it, a substantial donation being made annually.

**537. Some firms protect** themselves by liability insurance, in those states which are without definite compensation laws. Here an outside company agrees for a certain annual sum per employee depending on the hazard of the occupation to relieve the firm of all liability in the matter of accidents and fight it out with the man injured. Since these companies are in business for profit which depends on the smallness of the compensation given to the injured it will be seen that while they protect the manufacturer they do just the opposite to the workman.

**538. Blanket insurance.** In some cases employees are insured collectively under a blanket policy. The following description of this form of insurance is taken from an editorial in the American Machinist, vol. 38, p. 497.

*Under this group life insurance plan*, all of the persons forming the group are insured collectively under a blanket policy. Only

the employees of business organizations of high grade are considered desirable risks. The conditions under which they work must safeguard health and body, and the environment, and living conditions must tend toward permanency of employment. If the group numbers 100 or more lives, no medical examination is required if its waiver is permitted by the state insurance laws. For a smaller number, however, such an examination must be made, although it need not be as rigorous as for an individual life.

When a blanket policy under this plan is taken out by a firm for its employees, the amount of insurance for each is based on the yearly earnings, usually with a maximum limit. A single year's salary or wages is commonly taken as this amount although in one case this has been made equal to two years' earnings. The form of insurance is the yearly, renewable-term plan providing for pure insurance protection, and has no connection with sick benefits or accident compensation.

*The advantage of this plan* is the extending of the benefits of life insurance more generally, economically and effectively than is possible through individual insurance. Means are furnished whereby an employer can provide insurance protection to every employee to safeguard him during active service. In the organization whose size and permanency are insufficient to make it dependable for pension purposes over a considerable period, this group insurance plan is a practical provision underwritten by a responsible company. The blanket policy written for the Jones & Lamson Co. covers everyone in the company's employ, including the officers. The amount in each case is fixed at one year's salary with a maximum of $2000. Medical examination of the persons forming the original group was waived, but every new employee must submit to an examination before coming under the provisions of the policy. When an employee leaves the service of the company his insurance privileges cease. The premium is paid monthly and is based upon the number of employees and the amount of insurance of each.

Thus far this form of insurance has been taken up extensively by banks and trust companies. In general, the yearly premium can be approximated at about 1½ per cent. of the yearly pay-roll.

**539. An industrial pension plan.** After a thorough consideration of various pension plans, the R. Wallace & Sons Manufacturing Co., of Wallingford, Conn., recently inaugurated a system of pensions that has much to commend it both from a humanitarian and industrial point of view. It is proposed to leave the administration of the plan to a committee of three, either officials or employees, or both, to be appointed by the president.

Under the proposed operation of the system all men who have been 20 years or longer in the service and have reached the age of 70, and all women who have seen similar service and have attained the age of 60 may be retired and pensioned.

A minimum of 20 years of service in a man attaining the age of 65, or a woman of 55 entitles such employee to be retired and pensioned either at his or her own request or at the request of the employing officer. Any employee accidentally incapacitated who

has seen 20 years of service may be pensioned at the discretion of the company.

Pensions will be computed monthly on the following basis: For each year of service 1 per cent. of the average monthly pay received during the last 10 years of service.

Reports of employing officers wishing to retire employees coming under any of the provisions of the plan set forth are required to make a full report of the length of service, and the like, to the officers of the company, whose powers in the matter of the action to be taken are discretionary. The same system of reports obtains with employees requesting retirement and pension.

Pensions will be paid only to those employees who have devoted their entire time to the service of the company Leaves of absence and temporary layoffs are not to be construed as breaks in the continuity of service. Neither is a dismissal nor voluntary absence to operate in reckoning such continuity, but the time thus lost is to be deducted in reckoning the length of service.

Pensions are to be paid weekly unless revoked and shall terminate with the last payment for the month in which the death of the employee occurs. No assignment of pensions will be permitted or recognized under any circumstances. Neither are pensions subject to attachment or other legal process for the debts of the beneficiary.

This pension plan is a purely voluntary provision for the benefit of superannuated or totally incapacitated employees; it constitutes no contract and confers no legal rights upon any employee. Under its terms employees receiving the benefits are permitted to embark in other lines of business but are prohibited from engaging in work similar to that of their former employment while in the service of the company.

The company reserves the right, whenever the basis named for pensions creates total demands in excess of the appropriations applicable to the purpose, to establish a new basis by reducing the pensions theretofore or thereafter granted, so as to bring the total expenditures within the amount so set aside. It further reserves the right to change the rules at its discretion.

## SANITATION

**540. Sanitation.** Proper sanitation of factories is as important as the safeguarding of machines within them. The dangers which lurk in improper sanitary conditions are as great as those in the unguarded machine and often more so because they are not apparent. Factory sanitation may be divided into the following topics:

- Ventilation. Heating.
- Lighting.
- Drinking water.
- Sewage.
- Dust and gas exhaust.
- Wash rooms and toilets.

**541. Ventilation.** The requirements for good ventilation are from 1200 to 2000 cubic feet of fresh air per individual per hour, the average used in calculating for machine shops being 1500 feet.

In cases where the ventilation must also take care of heat produced from furnaces and ovens, and the like, this amount may have to be increased.

**542. Shop ventilation** may consist of natural cross-current ventilation secured by open windows, or it may be produced by means of a fan system. In the latter case, the same apparatus is also used for heating in cold weather. A great many plants which use the fan system of heating in winter do not take advantage of the means of ventilation offered thereby in summer on account of the cost of running the apparatus.

Fan ventilation is usually by means of blowers which force the air through the building, delivering and distributing it at a number of points by means of galvanized iron ducts. The proper place for delivery of air for most efficient ventilation and heating is near the floor.

**543. Exhaust systems** of ventilation are used in cases where obnoxious odors and gases are to be removed. Galvanized iron ducts and hoods are used to convey the gases from point of origin to the point of disposal. It is figured to obtain a velocity of from 75 to 250 feet per minute over the surface of such goods according to their location, the closer to the point of origin of the fumes, the less being the velocity required.

Sometimes both the blowing and exhaust system are used in conjunction, as in the case of boiler rooms where cooling is necessary to make the atmosphere endurable. An air change equivalent to a 3-minute supply and a 4-minute exhaust are recommended for boiler rooms, although these figures vary according to other conditions and are averages only.

**544. Heating.** Machine-shop heating is generally accomplished either by steam radiators or the fan system. The former is usually confined to the smaller plants on account of the cost of piping and radiators, although a number of large plants are heated satisfactorily in this way. In general however the fan system is applied to large plants and consists of a set of heater coils containing steam, the air being either blown through or drawn through the openings between coils, by a fan, and delivered through ducts to various parts of the buildings. The exhaust-through type of apparatus is the more compact and is therefore usually adopted for factory heating. Where variation in the temperature of air delivered to different departments is desired, the blow-through type must be used. A by-pass for cold air which does not pass through the heater may be used to temper the air delivered from the heater to any duct, thus securing the variable temperature desired.

**545. Air washing.** A number of types of apparatus are on the market for the purpose of cleaning the air which is used for heating and ventilating purposes by means of passing it through sprays of water. The excess of moisture is removed by passing the air through baffles after this process, which reduce the degree of moisture or humidity to between 35 and 50 per cent. Automatic means of controlling both the humidity and the temperature are supplied so that these factors may be maintained fairly constant.

Air within buildings may also be cooled in this manner from 10 to 15 deg. below that of the outside air.

**546. Proper lighting.** Proper lighting not only helps toward accuracy of work, increases production, aids toward prevention of accidents, but is also all important in conserving the eyesight of the employees. The attainment of proper lighting is not restricted to the original selection of the system employed but also depends on its proper maintenance.

**547. Drinking water.** It is becoming a general custom to furnish employees with cooled water during the hot months. For this purpose many types of coolers are on the market. It is not difficult to construct one or more of these since the principle of all of them is a coil surrounding or surrounded by ice and in contact with it. The length of the coil and the demands made upon the system determine the degree of cooling of the water. Stone and sand filters are sometimes used in connection with the water supply.

Bubblers or spouting fountains form the most sanitary method of conveying the water to the workman. In laying out a drinking water system, the location of the bubblers should be carefully planned to reduce to a minimum the average distance travelled by the workmen, who particularly in hot weather, make quite a number of trips for drinking water in the course of a day.

**548. Sewage.** Proper sewage is essential for the maintenance of sanitary conditions. Special attention must be given that there is no opportunity for sewage to contaminate the water supply for drinking purposes, particularly where spring or well water is used for this purpose. A precaution that is important is to carefully map sewer lines when laid as otherwise the location becomes lost after a number of years and great inconvenience is caused when it is necessary to dig to locate leaks or breaks.

**549. Toilets.** Toilets should be totally enclosed and provided with an exhaust system of ventilation or ventilating stacks running up to the roof of the building. This arrangement depends largely on the general sewer system. Urinals are sometimes detached from the closets and are disposed through the plant at more frequent intervals to reduce unnecessary steps and as a means of eliminating loafing.

Toilets often take up valuable manufacturing space. In one plant this is avoided by placing them upon platforms, the space underneath being used for storage of parts.

Sanded finish for toilet walls is desirable due to the difficulty of marking or writing upon it with lead pencils.

**550. Compensation for sickness.** In machine shops and other related industries, the only compensation for sickness to employees who are paid by the hour or the day consists in what they receive from mutual aid or benefit associations. The following is a description of a typical mutual benefit association as described by H. C. Wight in the American Machinist, vol. 37, p. 954.

The Mutual Benefit Association of the employees of the Platt Iron Works Co., Dayton, Ohio, at present has over 400 members, or two-thirds of the men on the shop pay-roll. During the first year, the receipts were $960.69, and the expenditures $610.69, which left a balance for future

liabilities. The good done is best described by stating that the average benefit was $22.10, or 41 per cent. of the pay lost by the men on account of their disability. This amount may seem trivial at first glance, but in most cases it was the only income and went for food and house rent.

The dues paid by the men work no hardship. The initiation fee of $1 includes the first month's dues. Afterward the cost is but 25 cents a month. The benefits come when they are appreciated and are as follows: Fifty dollars in case of death. This sum is paid within 24 hours; and $5 a week in case of sickness or accident. This is paid every 2 weeks after being approved by the executive committee, and continues as long as the employee is unable to return to work, up to 13 weeks. After 13 weeks the employee is reduced to "half benefit," which continues till recovery or death.

All claims are investigated, first by the visiting sick committee and then by the executive committee, thus lessening the liability of fraud. It is an association of the employees, managed by employees. The men cannot fail to see what it does for those who need assistance and so the factory where such protection is afforded becomes a better place to work. The management is benefited, as the men are less likely to move to some other factory on slight provocation.

Dangerous appliances about the plant are watched by all the members of the association, as these mean additional risk. A fair percentage of factories now have some sort of a relief association. Before organizing, a large number of these were investigated. The results obtained made the question not: "Should every factory have such an organization?" but "Can any factory afford to be without one?"

A number of the details that have been worked out are worthy of mention. Printed application blanks and sick notice cards are furnished to each member. The constitution and by-laws are on the back of the application blank. The following questions must be answered: (*a*) Married? (*b*) Age? (*c*) Ever had insurance application rejected? (*d*) What medical advice has been necessary in the past 2 years? (*e*) Nature and time of confinement during the past 2 years?

A constitution is given to each member on payment of the initiation fee. In case of loss a duplicate may be obtained on payment of 10 cents. Each member is also provided with a postal card to be used in case of sickness or accident. This is addressed to the secretary of the association and gives the name and address of the sick member on the back of the card. It should be mailed within 3 days. Upon receipt of the notice the secretary appoints a sick committee of three living near the indisposed member, whose duty it is to visit him at least once a week and report his condition to the secretary in writing after each visit.

The constitution provides for management by an executive committee consisting of the four officers who are elected at the annual meeting of the association and three members appointed by the president and vice-president. This board serves for 1 year. The members meet twice a month or oftener if necessary, pass on all benefits, and transact all necessary business. They are limited to a cash balance of $200. Everything above this sum must be turned over to the trustees of the associtaion who look after its investments. A trustee is elected every year and serves for 3 years.

To further protect the association, it was necessary to have the pay lost when absent exceed the benefit received, as otherwise some of the boys earning less than $5 per week could take vacations and plead illness. We have a second class of membership, which costs 15 cents per month and pays $2.50 benefit. This class is open to all whose weekly pay is less than $6 per week.

The method of collecting the money is simple and satisfactory. The initiation fee of $1 must be paid in cash by the candidate. This settles any question about the membership being voluntary. The monthly dues are taken from the pay checks from lists furnished by the secretary. This collects all of the money, collects it on time, and with the least possible trouble.

One excellent feature of some of the larger associations is in having the association doctor attend all cases. One of our present main troubles is with the doctors. In doubtful cases, where the person claiming benefits apparently takes a vacation at the end of a brief illness or is merely indisposed; we require a doctor's certificate. This does some good, though where there is a tendency to take advantage of the association, the doctor often upholds the patient, for if the patient fails to get the benefit the doctor has less chance of collecting his fee.

Any large association of 500 members or more looks attractive to any good young doctor. The salary is from 75 cents to $1 per year for each member on the books. This makes a fair salary for part of his time and also gives him the practice essential to later success.

He makes all house visits to sick members free, and gives office advice at half his regular prices. This small charge prevents members from going to the doctor when they are not really in need of attention. The successful doctor not only has the free trade of all members, but gets the family practice as well.

In spite of the cost, the association saves money by having a paid doctor. Naturally the doctor works to get his patients well as soon as possible, especially if he gets nothing for the visits. This reduces the amount of benefits that have to be paid. Further, the association providing free medical attention is a more attractive proposition. This means a larger membership and guarantees the maximum of good.

Other work may be annexed by the relief association. Ours has charge of the factory picnic in the summer and of the mid-winter entertainment. In organizing such an association, it is often best to suggest it to some good man who will start the movement with the coöperation of the company officials. The association means doing good where it is needed. It means help for the company by building up a spirit that will increase the efficiency of the organization.

**551. Sterilizing cutting oil.** Cutting oil which is used over and over again becomes a culture for all kinds of germs, and often results in blood-poisoning in the case of cuts. C. A. Tupper describes methods of sterilizing the oil in the American Machinist, vol. 40, p. 487.

"During the past 18 years or more I have been connected with a number of concerns operating large machine shops, and for a brief period, while dissatisfied with the opportunities apparently offered by the metal-working industries, was led to take a position as inspector and claim-adjuster for an employers' liability company. Hence, the subject of accidents and injuries to shop operatives has always been of interest, and this still finds an outlet in observation of the improved methods that have gradually been developed for safeguarding the lives and health of employees.

Among these methods one of the most important has just begun to come into use. It originated in the reclamation of cutting oil as an economical proposition, but its scope has been widened by the sterilization of the oil before it is used over again.

In handling accident cases it was formerly, and probably still is, the common experience that trivial injuries frequently resulted in the heaviest losses to employers or to the insurance companies, by death, amputation or protracted illness, owing to the fact that blood-poisoning set in. The reasons for this we ascribed to various causes—almost any, in fact, but the true one; yet looking back over the cases that came under my observation, I can recall that most of them developed when men operating machine tools sustained cuts, or abrasions, on their arms or fingers, and after wrapping a rag around them, kept on working. In the light of recent developments it now seems practically certain that this blood-poisoning was caused by germs in the cutting oil, with which the hands and arms of the men came in contact. A great deal of this oil was in filthy condition, from the scrapings, floating dust, dirt and careless spitting of the men, literally forming a "culture" for all kinds of germs. How much of the current illness was due to this cause, and how far ntagious diseases were transmitted, can only be a matter of

speculation; but these were not ordinarily made a basis for damage claims. Cases of blood-poisoning, on the contrary, came within the employers' liability, as growing out of injuries sustained in service; and some defect in the apparatus operated or absence of suitable protection could always be alleged as a basis for suit where settlement was not affected.

Had we known then of the cause to which such cases could be most directly traced, it would have meant a saving of many thousands of dollars and of the lives or health of numerous employees.

The same conditions, however, obtain to-day and a remedy for them ought, wherever possible, to be provided. The simplest and most obvious is the frequent renewal of the oil and its sterilization.

A number of devices for extracting oil from the chips and shavings are available, some being of the centrifugal type and others steam operated. Where steam is used it is also usual to install a water evaporator, so that the animal oil which emulsifies with the water will be restored, as such a mixture, if allowed to mix with the supply to the cutting tools, is injurious to them. Its presence is indicated by foaming.

For cleansing and sterilizing the oil, as drained off or extracted, an efficient system has lately been installed by the Timkin Roller Bearing Co., Canton, Ohio, and other concerns of the Central West. This consists of a series of tanks, the first of which are long and narrow and stand on end. Steam coils placed inside them raise the oil to a temperature where its complete sterilization is effected. The oil then flows to other upright tanks, with cone bottoms, in which the impurities are precipitated by settling, and it next passes to storage tanks. From these the daily supply is drawn off by measuring pumps, for re-use as needed.

With most plant managers, in arranging for oil-reclamation systems, the idea of economy is paramount. This is manifested not only by conservation of the supply but also in the longer life given tools by clean cutting oil. To my mind, however, the feature of sterilization as a safeguard to the health of employees has equal or greater importance, and it should always be provided for. For small shops, where the expense of special apparatus does not seem to be warranted, the slow draining off of the oil into an ordinary filter, with subsequent sterilization in a steam-heated container of any sort, will be sufficient; but for a plant of any size some such system as that above described is a real economy."

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